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SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

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WITH ESPECIAL REFERENCE TO
THE EFFECTS OF HUMIDITY

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GEOGRAPHIC VARIATION IN BIRDS.

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PART I.—HISTORICAL.

It has long been known that many mammals, birds ana reptiles inhabiting a moist, humid region show a much darker or increased pigmentation of the hair, feathers or scales than individuals from dryer localities. In cases where there are barriers isolating the humid forms, they are recognized as of specific or of subspecific value. Even where perfectly continuous intergradations are found, reflecting the gradual transition from lesser to greater humidity, each extreme type of the series, and occasionally several central forms, are differentiated by the systematist.

Correlated with this darkening of the epidermal structures, is frequently a distinction in point of size, either of the body and skeleton as a whole, or superficially, as of longer or shorter feathers of the wings and tail. The two best known and most often quoted examples among birds in our own country are *Colinus* and *Melospiza*—the bob-whites and song sparrows. Certain species of the mammalian genera *Canis* and *Sciurus*—wolves and squirrels, show this regional or climatal variation well, and among the reptilia, *Eutaenia* and *Crotalus*—the garter and rattle snakes—are especially susceptible to climatic influences.

These facts of distributional variation were enunciated anew in a recent interesting discussion in *Science,* from which I shall quote a few significant paragraphs.

Speaking of the climatic or geographic variation mentioned above, Dr. J. A. Allen says:—"Secondly, and coincidently with the decrease in size southward, is a change in coloration, which may be described in general terms as a restriction in area of all white markings and a corresponding increase in the area of the dark markings, together with, generally speaking, an increase in the intensity of color in markings or areas of other tints than black or white, as yellows, greens, browns, etc., and also in iridescence, in birds of metallic tints. * * *

"It is equally well known that in continently dispersed groups, pallid tints accompany desert areas and arid conditions of climate, and that increase in depth of color, particularly in gray, brown and olive tints, is an inseparable accompaniment of regions of heavy rainfall and a moist climate, so familiarly illustrated in the northwest coast region of North America. * * * In other words, regional areas of peculiar climatic conditions impress upon their animal inhabitants a certain distinctive phase of coloration, developing in some instances wholly new specific types, in others merely forms that intergrade with others of the immediately adjoining districts."

Near the end of the same article we read that Dr. Allen believes that the evolution of species and races has been brought about chiefly by environment, as opposed to natural selection—used in the original restricted sense—and that the main factor in this evolution is climate.

Two months later in a second article Dr. Allen thus argues for the inheritance of local differences in color of subspecific value:

"Young mammals in the nursling stage have a pelage different in color and texture from that later acquired; young birds have a characteristic nestling plumage different in color and texture from that of the adults, or from that acquired with the first moult. Every experienced mammalogist and ornithologist knows that the local differentiation in color between the subspecific forms of a group is often—but not always—much more strongly expressed in the first pelage or plumage of the young than in the adults of the same forms. In view of such facts it seemingly goes without saying that local differentiations are transmitted from parent to young, and are hereditary in the usual sense of that term; doubtless no one questions their continued transmission from generation to generation so long as the environment remains stable. Probably also few would question that were representatives of a strongly marked local form—in the case of birds, either as eggs or mature birds—to be trans-

planted to a region markedly different climatically from their natural home, they would gradually lose their original characteristics, and become, after a number of generations, more or less modified, in better agreement with the new conditions of life. But it would be apparently rash to expect a very material change in a single generation. There is apparently not the least probability that an egg of a large dusky Vancouver woodpecker taken to Arizona would hatch into a smaller pale form like the race native to Arizona."

Dr. Allen then goes on to tell of the stocking of northern preserves with the smaller, darker bob-whites from localities farther south, and states that no change in size or color has been observed. The same is said to be true of the bob-whites—supposedly Floridian—which, one hundred years ago, were introduced into Cuba, although there are now found in Cuba "quail that are intermediate in characters between the true Cuban form and the Florida form, due possibly to interbreeding but also possibly to the action of environment upon the introduced Florida stock."

In a continuation of this discussion in a later number of *Science,* Prof. T. D. A. Cockerell writes in the concluding paragraph of his article, "Finally, it is by no means to be assumed that the 'effects' of climate are necessarily direct, and not brought about through the agency of natural selection."

In a note at the conclusion of a paper on "The Variation of *Eutaenia* in the Pacific Subregion" Mr. A. E. Brown says, "That humidity in some way influences the metabolic processes which lead to pigmentation can hardly be doubted. Temperature need scarcely be considered in the present case, for the dry region, extending from Arizona to northern Montana, and to considerable elevations, has a very great thermal range, while the wet region is relatively equable. There is a suggested connection between the large amount of uric acid produced by reptiles and the fact that the yellow and orange coloring matter from the wings of certain butterflies has yielded a substance closely related to uric acid, but physiological chemistry is not yet competent to explain how these waste products are converted into pigments."

Folsom contends in the case of insects that the "effects of climatal influences and of nutrition are frequently adaptive and often transmissible, as experiments have proved. There is, however, much difference of opinion as to the precise way in which these effects are transmitted."

"Upon members of the Animal Kingdom," writes Dr. H.

M. Vernon, "observations as to the effect of moisture are exceedingly meagre. This is probably attributable to the fact that in most cases a direct effect is either slight or wanting. * * * In any case, the effect is probably an indirect one, acting through the vegetation."

In the summary of a series of thorough and very significant experiments relating to the effects of temperature and moisture on various species of the Coleopteran genus *Leptinotarsa*, Prof. W. L. Tower draws the following conclusions which he believes hold good for all insects.

1—The different factors of the environmental complex do not have any specific influence upon coloration, but all act alike as stimuli, either alone or in combinations, to accelerate or retard color development, and thus to modify coloration in the following ways:

a—Toward melanic or albinic conditions, which are the most general and important in coloration.

b—Toward suppression or accentuation of particular color areas or groups thereof.

c—Toward changes in the colors themselves.

2—The factors most potent in the modification of coloration are temperature and moisture; soil and altitude act indirectly through moisture and temperature, while the influence of food, light, and other factors is very slight.

3—Any factor acting as a stimulus produces at once the maximum response which the deviation in the factor is capable of producing, and this maximum response remains constant as long as the stimulus is in force, but varies as the stimulus varies, and is lost when the stimulus is removed.

4—Any factor which deviates either above or below the normal has the effect up to a certain point of producing increased pigmentation, and beyond that point of retarding it.

5—Variations produced by the action of environmental factors during ontogeny always follow the laws of fluctuating variations. New combinations of color characters never appear as the result of stimuli applied during ontogeny, and the modifications found are all in the line of accentuation or reduction of the color characters natural to the species.

6—The variations produced in experiment resemble in their polygons of distribution and in their modal classes conditions found in nature in places or in seasons in which the conditions of existence are similar to those of the experiment; and a variation found in nature is to be interpreted as the result of a devi-

ation of some factor of the environment acting as a stimulus to produce a modification of coloration.

7—The variations produced by somatic stimuli are never inherited, no matter how long the stimuli be applied. They are therefore of no importance in evolution. They are of importance, however, in a consideration of the phenomena of place and geographical variation.

8—Species of high variability in nature are also highly variable in experiment, and conversely, those which are constant in nature are the same in experiment; hence the observed variability of a species is a good index of the presence or absence of somatic plasticity but is not necessarily an indication of its ability to produce germinal variations and become a factor in evolution.

"Permanent, heritable color modifications of *Leptinotarsa* have been found in nature, and are indistinguishable from somatic variations excepting in their capacity for being transmitted to subsequent generations. They, however, have no relation to the variations experimentally induced herein described."

Writing of the mutation theory in animal evolution, Prof. Davenport mentions black plumage and color of iris among other "discontinuous characteristics," and goes on to say, "One who sees the striking failure of these characteristics and many others to be modified in any important way will feel convinced that they are not capable of forming intergrades, and hence could not have arisen gradually."

I have quoted from these various authorities in full to show what diverse views on the subject are at present rife among biologists, and how little we actually know not only of the direct action of the various climatic factors of the environment, such as temperature, humidity and light, upon terrestrial vertebrates, but of the relative importance of these factors both in the ontogenetic and phylogenetic history of the various organisms. The most important phase of the subject and the one about which, if possible, we know least, is the difference of inception and assimilation of the various externally exerted stimuli, bringing about non-inheritable somatic variations on the one hand, and on the other, the heritable variations of the germ plasm; both, in many cases, superficially so similar, and yet in their cumulative influence so radically unlike in relative importance.

Concerning the radical effects of a new environment acting within historical times, Darwin relates of the Porto Santo rabbits, that in less than 440 years they had "decreased nearly three inches in length and almost half in weight of body," besides

changing considerably in color, especially in the ears and tail; these being reddish-brown instead of blackish. But when one of these feral rabbits, which had been confined for some time in the London Zoo, died and was examined, it was found that "under the English climate this individual rabbit had recovered the proper color of its fur in rather less than four years!"

In this instance, although the details are meagre enough, we have conclusive evidence of a radical—and to all intents, specific—change of color in the life-time of one individual, and a most surprising change in size and weight of the entire organism during a period of about 400 years.

In regard to the effect of humidity on insects, Marshall and Poulton, writing of the dimorphic seasonal forms of certain butterflies in South Africa, regard this as due to the alternation of dry and rainy seasons which there take the place of summer and winter.

Changes in the imago of moths and butterflies have been experimentally induced by subjecting both caterpillars and chrysalides to intense humidity. The artificial melanism induced in beetles of the genus *Leptinotarsa* by Tower has already been mentioned.

Dr. Allen in his article on Heredity and Subspecies, from which I have quoted, does not mention the instance of the bob-white in Jamaica. This bird, according to Gosse, was introduced upon the island from North America about 1747. As a whole, the race has been almost exterminated by the naturalized mongoose. I have recently received an interesting living specimen of the bob-white from this island, thus representative of an isolated island colony established 160 years ago. Difficult as comparisons are when the subject is alive and energetic, and when its rarity renders even a cursory handling very dangerous, I have made as careful an examination as possible, and compared it as regards color and measurements with typical specimens from the north and from Florida.

In the Jamaica bob-white, a male bird, the white forehead and superciliary stripe are variegated with black, and the red on the head, while very intense, is confined to the extreme tips of the feathers. In a typical northern bird in unworn plumage the red on these crown feathers comprises some 5 mm. of the distal portion, while in the Jamaica bird this color is reduced to 2 mm.

The ear-coverts and sides of the head are almost uniformly black, while the throat is variegated, being about half white and half black. No intermediate grays are present here, the two ex-

tremes of color being in sharp contrast to each other. The black cervical band is very wide. The greater wing coverts, instead of showing vague slate-colored markings, are crossed by clear-cut transverse bars, while the doubly crescentic black bars on the feathers of the under parts are twice as broad in the Jamaica bird as in the typical northern bob-white.

Black predominates on the inner tertials and the buff edgings of these feathers are wide and very intense. The feathers of the back and tail coverts are dark, while the tail feathers themselves are almost black. Everywhere on the body and wings the red color, where not replaced with black, is deep and intense, a rich rufous much as in *Colinus cubanensis.* The wing of this bird measures 4.25 inches and the tail 2.25 inches, these measurements being considerably less than in birds from the north.

The quail flourished on the island until the mongoose was introduced, an animal which increased so rapidly as almost to exterminate the terrestrial mammal and bird fauna. The result of this is that to-day the quail are very rare, there being but two or three small covies scattered over two restricted districts. A recent observer estimates the total number of birds on the island at not over 70.

Although dark coloring in southern humid regions is often accompanied by a decrease in size, rarely by an increase, there is, as I think my experiments on *Scardafella* show, no necessary intimate correlation between the two phenomena. That of size may indicate, as Dr. Allen suggested thirty years ago, the course of adaptive radiation; the larger forms representing the hypothetical center of distribution. But size may or may not be significant of long existing conditions (cf. the Porto Santo rabbits, p. 7), while, as we shall see, geographical variations in color, even after long continued exposure of generations to an extreme of climate (*Scardafella inca,* in Mexico and Arizona) may prove to be of the most plastic and evanescent character.

Part II.—Dichromatism.

The more or less regular occurrence of black or dark-colored individuals among wild birds is known in many instances. From these I shall select a few of the more significant. The Old World snipe *Gallinago gallinago* ranges over Europe, Asia and North Africa. Fifty-five melanistic specimens are known in collections, so-called *G. sabinii,* of which thirty-one were taken in Ireland, twenty-two in England and one each in Scotland and on

the continent of Europe. Here we have an interesting case of the localization and the restriction to a humid region, of a melanistic form, race or variation, whatever we choose to call it in the present state of our knowledge. The rough-legged hawks and fulmar petrels, *Archibuteo* and *Fulmarus,* of America, and the parasitic jaeger, *Stercorarius parasiticus,* also exhibit a dark phase which is independent of age, sex or season.

A well known example of rather unique occurrence is found in *Pavo nigripennis,* the black-winged peacock, in which almost the entire wings and thighs are black. This form has never yet been observed in a wild state, but in flocks kept in semi-domestication, it occasionally crops out, and though weaker and less hardy than its parents, typical *Pavo cristatus,* yet it is said that if left to interbreed, this melanistic form will gradually become dominant and ultimately supplant all of the normally colored birds. Ogilvie-Grant says of this bird: "Although this variety closely resembles the male hybrids between *Pavo cristatus* and *P. muticus,* it has been clearly shown that it arises independently in flocks of common peafowl which have been pure bred for many years, and there can be no doubt that it is merely a sport of nature, possibly due to atavism or reversion to the ancestral type, from which both the common and the Burmese peafowl have sprung."

The black hawk, as the dark phase of the rough-legged hawk is called, *Archibuteo lagopus sancti-johannis,* while appearing during migration as isolated individuals all over the United States and southern Canada, seems to have a center of abundance in Ungava and Labrador. The Storers found the black hawk not uncommon on the cliffs of Labrador and their "observations of its habits, as contrasted with those of the still more common rough-legged hawk, left no doubt in their mind of their specific distinction. While the black hawk was observed to be a bold, vigorous and spirited bird, easy and swift in its motions, and preying upon other birds while on the wing, the rough-legged was comparatively sluggish, inoffensive and subsisted only upon rats, mice, moles, frogs and other small game. A nest containing young birds was found and one of the latter caught alive. Both old and young were in the same black plumage. The young hawk was fierce and intractable, and its whole air and manner were utterly unlike the conduct of the young of the other species." It is difficult to account for this reputed difference in mental character correlated with distinction in color phase, unless the observers were deceived by the marked individuality of a few birds.

Among many hundreds of rough-legged hawks sent to the Smithsonian Institution from the Arctic regions, not one was in the dark phase. But in the Ungava District, east of Hudson and James Bay, they are said to be common. Of one hundred birds killed within a short time at Toronto, five were black hawks. The extreme type of each phase has the young and adult plumage distinctly marked, but these are connected by individuals exhibiting every gradation of intermediate characters.

Although not dichromatic in the sense of the different color forms inhabiting the same regions, yet the common red-tailed hawk, *Buteo borealis,* should be mentioned here as a type of subspecific geographic variation found in many groups of birds. In eastern North America this hawk is subject to comparatively little variation, but in the west and southward, through Mexico, it presents widely different phases. In the central United States a very light colored phase is known as the subspecies *krideri,* while a Pacific and Mexican melanistic and erythrystic phase has been named *calurus.* The young of all the forms appear to be indistinguishable and the adults differ from one another in neither size nor shape, but only in the pigmentation of the feathers.

As regards the group of jaegers or skuas, *Stercorarius,* dichromatism seems to exist in almost all. *S. pomarinus* has two very distinct color phases, one almost wholly sooty-brown, the other particolored, dark above and white on the breast. This condition is duplicated in *S. parasiticus* but in the closely related *S. longicaudus,* only one, the white phase, is commonly seen, although there is one record of a dark individual of this species.

In the two first mentioned species, a particolored bird may be frequently found mated with one wholly dark, in fact it is said that both partners are rarely alike in their phase of plumage. As in *Archibuteo,* the distinction depends neither upon age, sex nor season.

In the *Procellariiformes,* which include the albatrosses, fulmars and petrels, dichromatism is a common characteristic, as among *Ossifraga* and *Fulmarus.* In the latter birds an important fact is the tendency toward geographical isolation of the two phases, the dark phase, in both the Atlantic and Pacific birds, being predominant toward the west.

Uria troile, the common murre, has an interesting color phase which is said to occur in from one out of twenty to as high a ratio as one out of five individuals at the vast breeding rookeries of this species. These less numerous birds were formerly thought to be distinct and were named *ringvia* and *lacry-*

mans, but they are now recognized as only a color phase. In distinction to the others they have a white ring around the eye and a white stripe leading back from it. No intermediate types are known; the murres either possessing the circle and stripe fully developed or being wholly without it. On our coast the murre breeds along the sea-cliffs from Nova Scotia northward. It is said that in the Californian subspecies this white phase is never found, although it is present in birds of Europe and Asia.

The status of *Chen hyperboreus* and *C. caerulescens,* the snow and the blue goose, has long been a puzzle to systematists. *C. hyperboreus* is pure white in color with black tips to the primaries. The immature bird closely resembles *C. caerulescens,* having a light head and neck, but with all the upper body plumage dusky or bluish-gray. For many years the blue goose was thought to be merely the young of *C. hyperboreus,* but ultimately both were considered to be true species, and in the check-lists to-day are so listed. But word comes indirectly from Prof. F. E. Blaauw, of Holland, that he has obtained *C. caerulescens* from eggs laid by *C. hyperboreus,* and vice versa. This would indicate that, if indeed the two geese breed true and by themselves in the Arctic regions, one of the forms is of comparatively recent origin. We know nothing of the nest and eggs in nature of *C. caerulescens* except from the report of the Esquimo that its home is in the inaccessible *humid* bogs and swamps of the interior of Labrador. It is said that the blue goose "crosses James Bay, in the southern part of Hudson Bay, coming from the eastern coast, while the snow goose comes down from the north, seeming evidently to indicate that their breeding places are distinct."

If the various facts above related concerning these two forms of geese are correct, and if the intra-specific occurrence of such dichromatic phases as these, adumbrates new and permanent forms, we have an interesting and significant stage of species formation by geographical variation. The status of the forms of *Chen* may, from such a point of view, be considered as somewhat more advanced than the condition in *Gallinago, Archibuteo,* and, as we shall see later, in *Felis pardus.*

Although, and this is an important point, while in these latter forms the dark phase of distributional variation is subordinate to the normal type, and at the same time congenital and of recent evolution—perhaps an incipient species—in the case of *Chen* the fact that *hyperboreus* in its immature plumage closely resembles *caerulescens* would seem to indicate that the latter phase—or species—is the more primitive and ancient, and is per-

haps being supplanted by the white type.* In other words, if *Chen caerulescens* and the dark phase of *Gallinago gallinago* were bred in captivity from *C. hyperboreus* and from normally colored *Gallinago,* we should be inclined, in the present state of our knowledge, to consider the former an atavism, the latter a recent variation.

I have taken this theoretical point up in some detail to show the possibilities of species-formation from distributional variation—on the one hand (*Gallinago*) a humid phase evolving in a restricted locality from a widely spread typically colored species, and in the other case (*Chen*) a form, local at least in its present distribution, perhaps immediately ancestral to a lighter type of bird, which, in one or the other of its two intergrading subspecies (*C. hyperboreus* and *C. h. nivalis*), is circumpolar.

Examples which have apparently attained the final step in species demarcation, but which are separated specifically by only the single character of a difference in color, are the white and the scarlet ibises *Guara alba* and *G. rubra,* and the great white and the Ward heron *Ardea occidentalis* and *A. herodias wardi.* These are said to be specifically identical in all characters except the pigmentation of their feathers.

Ardea rufescens, the chestnut and bluish colored reddish egret and *Ardea pealei,* a pure white bird, were thought to be different species until the discovery of their interbreeding proved them to be only two phases of the same species. In this case, intermediate, particolored birds are not uncommon.

We shall pass over many other interesting cases of dichromatism in birds, and mention only *Falco sparverioides,* the Cuban sparrow hawk, which exhibits two very distinct color phases. I have had two living adult birds, one in the light and one in the dark phase, under observation for two years, having received them when they had not yet shed all their nestling down. With each succeeding moult there has been a more and more sharp demarcation between the coloration of the two types. The crown is the same color in both birds, but the pure cinnamon back of the light phase is so encroached upon by dark blue in the other bird, that the cinnamon is reduced to irregular and broken bars, present on only some of the feathers. In the dark bird the black area on all the wing feathers is increased and the parts of these feathers which are white in the light bird are

*The white color of the snow goose, homologous as it is with the same phenomenon in most other terrestrial Arctic birds and mammals, must not be confused with *albinism* to which it is in no way analogous. With this abnormal condition we have nothing to do in this paper.

wholly replaced with rufous in the other phase. In the dark bird, blue barring has appeared on the under primary coverts and subterminal spots on the feathers of the sides, while the entire under parts, from throat to tail coverts, is a deep cinnamon, very different from the white, slightly rusty-tinged, ventral feathering of the light bird.

Our knowledge of these two forms in the living wild state is very meagre. They have been known to breed together, and young birds of both colors have been found in the same nest, but Mr. Chapman records that of all the pairs he observed breeding in Cuba, in no case was a dark bird paired with a light one, or vice versa. The most interesting fact in regard to this dichromatic species is its extreme localization. Closely related forms of *Falco* are found throughout the other West India Islands and in most of North and South America, and yet outside of Cuba there is no tendency shown to develop distinct color phases.

To refer parenthetically to geographical melanism in the mammalia, we find a number of examples paralleling in many respects the avian case of *Gallinago*. Partial and wholly melanistic individuals of the jaguar, *Felis onca*, are not uncommon in northern South America, being most abundant, according to Humboldt, in the humid region of the Orinoco, while to the southward these animals become more yellowish or even whitish in color. It was formerly thought that this dark phase was a distinct species and the name *Felis nigra* was given to it by Erxleben. The best known case of melanism among mammals is the leopard, *Felis pardus*. Intermediate phases are rare, the melanism being usually so complete that the entire animal is uniformly black, the rosettes being visible only in certain lights. In the northern part of the leopard's range in Asia the black phase is unknown, but in the southern, more humid regions, the number increases until the center of their occurrence is reached in Singapore; Assam, Sumatra and the Malay Peninsula being the home of nine out of ten of these animals. I can discover only six references to melanistic individuals of the leopard in South Africa. The name *Felis melas* has been applied to the black leopards, but there is no question of the specific identity of these and the normally colored individuals, since the occurrence of both spotted and black cubs in the same litter has been again and again recorded.

One of the most interesting cases among the mammalia, and one for which at present we can offer no satisfactory explanation, is that of the big-horn or mountain sheep of western North

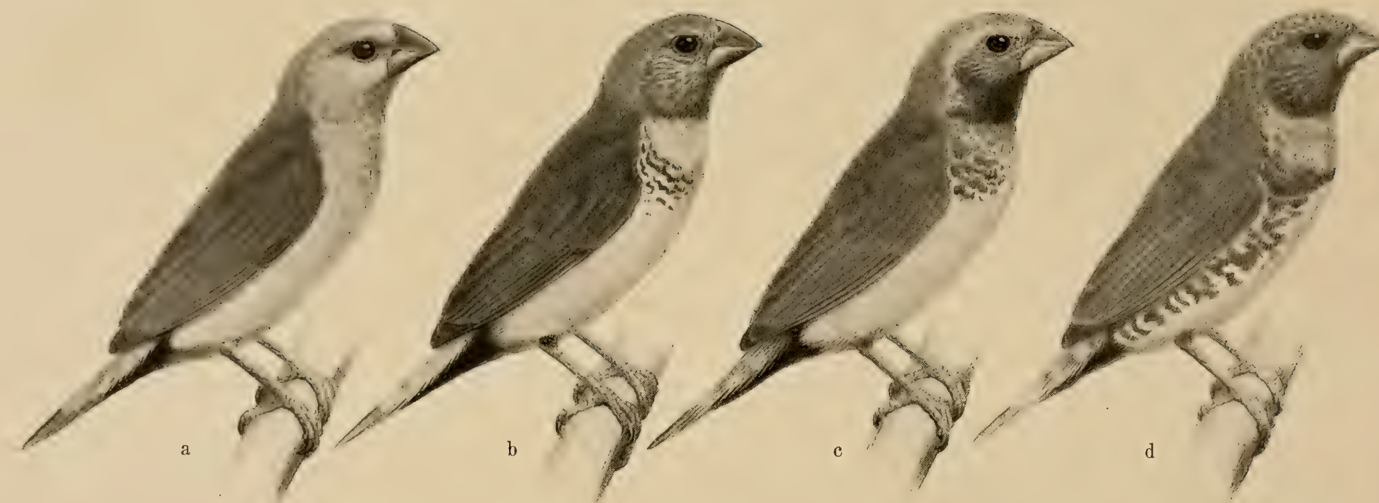

Fig. 1. Typical examples of (a) the Yellow-rumped Finch, *Munia flaviprymna*, and (d) the Chestnut-breasted Finch, *M. castaneithorax*; and examples (b and c) of *M. flavipyrmna* which have partially assumed the plumage of *M. castaneithorax*.
(Courtesy of Mr. Seth-Smith.)

America. Mr. Charles Sheldon writes me as follows concerning the occurrence of the black and the white forms: "I am certain that at some points the same mother has black and white lambs—that a white mother has a black lamb, that a black mother has a white lamb; at such points, however, none of the sheep are pure white or pure black. Moisture has nothing to do with their color. Where the black forms are found, the climate is the same and as dry as in the habitat of the white sheep. On the north side of the Alaskan range the sheep are uniformly pure white, yet living among glaciers and at an altitude where it is much damper than where the black sheep are found. Indeed, the rainfall is almost constant in the mountains in the summer."

While it appears impossible, in the present state of our knowledge, to correlate with more certainty the foregoing examples of melanism and dichromatism, yet we should keep them all in mind while endeavoring to interpret the results of future field studies or experimental researches along these lines. Whether mutation plays a part in the development of any of them or whether all are to be explained as arising by the accumulation of continuous variations, one thing is certain, it is upon one or both of the methods of work which I have mentioned, that we must depend for the elucidation of problems of this character. The collecting of thousands of skins will be of no service nor will the study of those now in our museums be of any direct use. We must have careful and minute tabulation of the ecological conditions under which the phenomena under discussion appear, correlated with the effects of similar, as well as intensified and modified, climatal and other factors, upon individuals under constant observation.

Part III.—Sporadic Melanism.

Many records of casual or sporadic melanism are scattered through ornithological literature, of which I shall cite only a few. In 1876 Mr. Ruthven Deane wrote that "melanism is of exceedingly rare occurrence, and but five species have been recorded on my list: *Turdus migratorius, Colaptes auratus, Melanerpes erythrocephalus, Orytx virginianus,* and *Uria grylle.*" Later, in 1879, he adds the Carolina rail to this list, and since then other writers have considerably increased the number of birds observed in a melanistic state, such as *Mniotilta varia* and *Strix flammea.* Many of these records have reference to wild birds, others to individuals bred, or at least reared, in captivity.

Melanism in cage-birds has received such desultory attention that as regards food, temperature and other environmental conditions, we are as much at a loss for definite details as in the case of wild birds.

Elliot Coues, W. B. Barrows, Walter Faxon and others have described melanistic American robins in captivity, some of which were congenital in the character of their abnormal coloration, while in other cases the dark plumage was assumed gradually moult by moult. In one bird, the normal plumage appeared during one moult, sandwiched in between melanistic moults, and when examined after death, the bones of this bird were found to contain only one-third of the normal amount of calcium phosphate.

Another robin which became "as dark as a European blackbird," was confined in an aviary built like a greenhouse and sloping south, a condition which might indicate that the bird lived in an atmosphere of considerable humidity.

In an article on "Notes on Melanism and Albinism in Birds," by Dr. A. G. Butler, the theory is advanced that melanochroism in old age is the result of unusual constitutional vigor. He instances a song thrush which had lived in captivity for sixteen years and had become quite black. Elsewhere he says that among thrushes and skylarks which have lived long in captivity melanochroism is not uncommon.

He does not believe that food has anything to do with melanism in captive birds, even doubting whether there is any truth in the oft-quoted case of darkening bullfinches by feeding them upon hemp seed. On the other hand, Distant quotes from Hasting's notes, that not only bullfinches but skylarks and other birds become black when kept upon a diet of hemp.

As a direct cause of local melanism in an individual bird, Dr. Butler tells of a female Martinican dove, *Zenaida aurita,* which had been persecuted by other birds until every feather had been removed from the lower back, and when, after removal to a cage by itself, these feathers were renewed they all proved to be perfectly black in hue. Renshaw was unsuccessful in restoring a nonpareil which had moulted yellow, to its normal coloring, by an increase of animal matter in the food.

Among the weaver birds, *Ploceidae,* some species are reported to become frequently melanistic in captivity and Salvadori observes that among doves, *Chamaepelia talpacoti,* when kept in confinement, often becomes partially or wholly black. Besides these there are many other records, all practically worthless on account of the total lack of clear, definite details of conditions.

I know of no definite experiments which have been carried out in respect to the plasticity of pigment supply in the epidermis of birds of any species; hence the results, interesting and significant as these are, of the few experiments I have undertaken, must be considered only as tentative until they receive further confirmation from future experiments by myself or by others.

Paralleling in many ways the results of my experiments on *Scardafella,* is the relationship between the yellow-rumped and the chestnut-breasted finches *Munia flaviprymna* and *Munia castaneithorax,* two members of the family *Ploceidae* or weaver-birds inhabiting Australia. Mr. D. Seth-Smith discusses this in an interesting article in a recent number of the *Avicultural Magazine.* There is little doubt but that these two birds are closely related, since their songs are exactly alike and the young, until three weeks old, are indistinguishable. The adults, however, are radically unlike in coloring, especially as regards the head and under parts. In *M. flaviprymna* these portions are pale creamy-buff, while in *M. castaneithorax* the sides of the face, ear-coverts and throat are blackish, the sides of the neck and body, fore neck and chest pale cinnamon, followed by a black band across the breast. Below this the plumage is white.

In captivity, specimens of *M. flaviprymna* two or three years of age have been known to assume gradually the markings of the darker species. It was observed of one individual after its fall moult, "the throat had darkened considerably and there were very distinct traces of a dark pectoral band." These birds were at first thought to be hybrids, but as the young of *M. castaneithorax* shows traces of the chestnut beast when only six weeks old and is indistinguishable from its parents at six months, the age of the individuals which assumed the new coloration would alone serve to disprove such a theory.

In summing up his conclusions on this significant change of plumage in captive birds, Mr. Seth-Smith says, "My own theory is, that *M. flaviprymna* is merely a desert form of *M. castaneithorax* which, to fit it for its desert life, has gradually lost the conspicuous markings of the latter. The changed conditions of a life in captivity and a more humid atmosphere, however, cause it, to a certain extent, to reassume the markings which it has lost on account of its desert life. Of course only a very few examples, perhaps not more than one per cent., ever do change color. Whatever the true explanation of the change may be, it seems to me that the two forms are *not* distinct species, but only local races, and in classification are only entitled to be ranked as sub-species."

An Australian trapper of large experience in taking these birds says he has never noticed any variation from the normal plumage in the respective habitats of the two forms, so this latter conclusion would seem at least open to reasonable doubt. However, I have elsewhere in this paper discussed in detail the taxonomic side of a condition such as this. By the courtesy of Mr. Seth-Smith I am able to present drawings of the intergradation of the two birds.

Part IV.—Experimental.

The experiments detailed in the course of the present paper are far from complete. They relate only to three species of birds, but the similarity of result in each case and the possible significance, in relation to certain factors of environment, in the evolution of birds as a whole, would seem to justify publication at this early stage. This part of the contribution may thus be considered as only preliminary to future, more comprehensive researches. The experiments were all carried on at the New York Zoological Park with birds living in the collection of the Society, and for the opportunity of making these studies I am greatly indebted to my chief, Dr. William T. Hornaday.

The early stages of the experiments were made under conditions which rendered it impossible to make other than temperature records, but later, hourly readings with a hygrodeik showed that, on the whole, the daily humidity was considerably greater than that of New York City. The mean annual humidity of the city is 73 per cent., while the average humidity to which the birds under experimental observation were subjected was 84 per cent. During the warmer months, from April to September inclusive, the temperature averaged that of the city, 68 degrees, while from October to March inclusive, it varied from 60 to 72 degrees.

Hylocichla mustelina (Gmel.), Wood Thrush.—In the spring of 1902 three young wood thrushes, nine days old and well feathered, were taken from a nest and reared by hand. Both parents were seen and were in every respect normally colored. Soon after the young birds were taken, the parents built a second nest and successfully reared another brood. The moult into the first winter plumage was completed by the tenth of September, and a little before this time, about the first of the month, two of the birds were placed in a very humid atmosphere. One of them died shortly afterward from some unknown cause, no lesions being discernible, but the second bird lived two years, when it met its fate at the beak of a pugnacious robin. In the early fall

of 1903 it moulted well, and although, when compared with skins of typical *H. mustelina,* the breast spots seemed larger and darker, yet there was too little difference to be considered, under ordinary circumstances, as more than individual variation. The death of the bird occurred on August 20, 1904, when its moult was not yet completed. Many of the feathers, however, are full-grown, and the remarkable change in amount of color which has taken place is perfectly apparent. (Fig. 2.)

The upper parts are but little changed, the rufous being slightly dulled by the olive tinge which extends as far as the nape. The most radical difference is to be observed in the feathers of the breast and sides. The general aspect of these parts is of a brownish black, variegated with narrow light edges to the feathers. On the breast the white is more apparent, some of the feathers having circular spots of normal size; but on the sides, flanks and under tail coverts, and even in the center of the belly, the black areas are almost confluent as the feathers lie naturally. The primaries and rectrices show a very pronounced lack of pigment—a tendency toward albinism which is unique among my experiments—albinism having in no other case resulted from a prolonged exposure to excessive humidity.

The third specimen of *H. mustelina,* which was taken from the same nest as the other two, is alive to-day, and in every detail is in perfectly normal plumage, having been caged with a number of other thrushes, outdoors in summer and during cold weather in the passerine hall of the large bird house. The food of both thrushes was the same, a mixture somewhat resembling the "mockingbird food" of dealers—a little scraped raw meat and earthworms; meal worms once a week, fruit, lettuce, chickweed and many kinds of berries.

In a natural state, wood thrushes do not show a great deal of variation, although in some specimens the pectoral spots are more numerous and larger than in others. This is said to be especially true of birds from Guatemala, and in an individual from the State of Tabasco, South Mexico, it was so pronounced that Bonaparte, in 1853, described it as a separate species under the name of *Turdus densus.* This shows that, among wild birds of this species, there is at least a slight tendency toward melanism under the effects of warmth and humidity.

Zonotrichia albicollis (Gmel.), White-throated Sparrow.—On the second day of October, 1901, two white-throated sparrows were trapped in the Zoological Park in traps set for English sparrows. They were both, as was eventually determined, males, and, judging from the dullness of the plumage, were young birds

of the year. One of these birds was immediately confined in the superhumid atmosphere of the experimental cage, while the other was allowed the freedom of a large outdoor aviary in company with song sparrows, tree sparrows, juncos and indigo buntings. The food was uniform in both cases, canary and millet seed with lettuce, and some insect food. No hemp was ever given.

In May, 1902, when closely compared, no difference could be detected between the two birds, and when placed together during examination in a cage, it would have been impossible to identify the individuals in order to return them to their respective quarters, if a primary had not previously been clipped from the wing of one.

In the following year, May, 1903, a radical change had taken place in the bird confined indoors. The general effect was much as in the yellow phase of the undulated grass parrakeet, *Melopsittacus undulatus,* only in the case of the white-throated sparrow it was a veil of darkness which appeared to be drawn over the normal markings. In October, 1904, both birds having completed their winter moult, they were chloroformed and made into skins.

The white-throat which had lived the three years of its life outdoors is in all respects normal, and, except in minor details referable to individual variation, the bird is indistinguishable from others in my collection.

The other specimen of *Z. albicollis* is melanistic to an extreme degree. The deviation from the normal coloration of these changes may best be appreciated by an examination of the photograph of the two birds. (Fig. 3.)

In the melanistic bird there is a considerable increase in all black and rufous markings, the latter color taking the place of the normal buff, gray and white. On the wings and body there is reduction or even obliteration of all yellow markings, and on the head and throat a similar recessive tendency of the white. It was recorded while making the birds into skins that the mandibles of the melanistic individual were deeply pigmented while the legs and feet were normal in color, and these characters are still conspicuous.

The gray of the breast remains almost unchanged, but there has appeared in this region a number of broad streaks of dark brown, almost black, which at the posterior edge of the gray area become confluent to form a large pectoral black spot. In the living bird these streaks and pectoral mark were especially noticeable, even more so than they are in the skin.

a b

FIG. 2. (a) Breast Feathers of normally colored Wood Thrush *Hylocichla mustelina;* (b) Breast Feathers of melanistic Wood Thrush.

FIG. 3. (Upper) Normal White-throated Sparrow, *Zonotrichia albicollis;* (Lower) Melanistic White-throat, three years in humid atmosphere.

Any speculation as to the significance of these streaks and spot would be of little value, based on this single experiment, but the following facts should be mentioned in this connection, whether or not future experiments give to them greater significance than they now possess. Similar markings, the streaks and pectoral spot, are present in the first winter plumage of *Z. albicollis,* being lost at the time of moult either into the first nuptial or second winter plumage, while they are entirely absent in the adult.

In the closely related *Spizella monticola,* the tree sparrow, a dusky pectoral spot is assumed with the first winter plumage and is a permanent character of the adult birds of both sexes.

Zonotrichia albicollis presents little variation throughout its range which comprises the whole of eastern North America, and no variations of subspecific value have been distinguished by systematists. This lack of variation is probably due to the highly migratory character of this bird, the breeding range being confined chiefly to the region from New York and Michigan northward to Labrador and Hudson Bay. *Zonotrichia querula,* the Harris sparrow of the middle United States, is the species of this genus which shows the largest amount of black in the plumage, the entire crown, throat and part of the breast being of this color. The close relation, almost congeneric, of *Zonotrichia* to *Junco* demonstrates that predominating melanic coloring is at least possible in some members of this section of the *Fringillidae.*

Part V.—Experimental—*Scardafella.*

A—*Normal Variation in Scardafella inca* (Less.) *Inca or Scaly Dove.*

The genus *Scardafella* embraces a group of small doves which extends as far north as southern Texas and Arizona and south to Brazil. The forms at present recognized by systematists are as follows:

Scardafella inca, Southern Arizona and the Rio Grande valley of Texas, south through lower California and other parts of Mexico to Nicaragua.

Scardafella i. dialeucos, known only from the boundary line between Honduras and Nicaragua.

Scardafella ridgwayi, Island of Margarita and coast of Venezuela.

*Scardafella r. brasiliensis,** coast of Brazil, south at least to Bahia. Nothing is known of its distribution in the interior.

* This southern form has not as yet been separated, but for the purposes of this list I have applied this term to the Brazilian birds.

From careful study of the general coloration of over fifty specimens it appears that there is no radical variation in the plumage as a whole in these doves from Arizona to Nicaragua. From this region southward there is a hiatus, if not in actual distribution, at least in the record of any individual of this genus. In Colombia, on the South American mainland, we find *Scardafella ridgwayi,* in which the white of the greater wing coverts is very strongly marked and the dark, scale-like tips of the contour feathers are nearly twice as wide as in the northern birds.

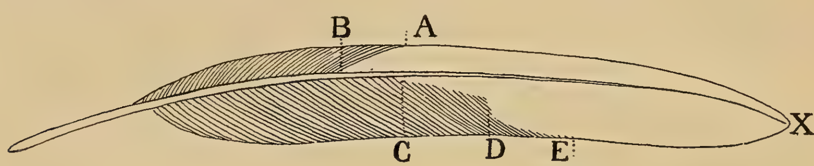

DIAGRAM OF FEATHER SHOWING MEASUREMENTS ON WHICH TABLES ARE BASED.

Disregarding the boundary line of species and subspecies for a reason which will appear later, and carefully tabulating the variations in specimens from different localities, a very apparent grading of certain characters is found from the Arizona to the Venezuelan birds. In Tables I, II, III and IV, which are self-explanatory, I have given the averages for the size of the blackish tips of the outer pair of primaries, and the white tips of the outer (or sixth), fourth and third pairs of rectrices. The figures are all in millimetres and the key to the method of measurement is given in the above figure.

TABLE I.

Geographical variation in the Blackish Tip of Outer Primary of *Scardafella.*

Locality	*Number of Specimens*	*Number of Feathers*	*A X*	*B X*	*C X*	*D X*	*E X*	*Average Area*
Arizona	10	18	32	41.5	27.3	20	17	27.5
Texas	12	22	30.5	36	23.8	19	17	25.2
North Mexico	12	23	31.3	36	26.3	19.5	16.5	25.9
West Mexico	10	20	31	33.7	19.8	17.5	15.2	23.4
Guatemala	2	4	29	32.5	19	17.5	16.5	22.9
Honduras and Nicaragua	1	2	25	15	14.5	15.5	14.5	16.9
Venezuela	9	18	52.3	52.8	25.8	19	17.2	33.4
Brazil	1	2	60	60	24.5	20.5	21	37.2

It is to be regretted that so few specimens were available for examination, fifty-seven all told, about ten from each group

locality, except Guatemala (2), Honduras-Nicaragua (1) and Brazil (1). But even with this unequal distribution the results of the various measurements are consistent and serve perfectly to demonstrate what I desire, namely, distributional variation in these wild birds.*

In the case of the dark, distal primary patch, which is shut off from the rest of the feather by the succeeding chestnut, there is a gradual decrease from Arizona to Nicaragua, indicative of the corresponding increase of chestnut. In Venezuelan and Brazilian specimens is found a sudden and extensive decrease of the chestnut; in fact, in the narrow outer side of the vane of the primaries this color is almost, in the Venezuelan doves, or wholly, in the Brazilian birds, lacking.

The white tip of the outer, or sixth, pair of rectrices shows a gradual increase in area southward, from 39.2 mm. in Arizona to 49.2 mm. in Nicaragua. The widest break is between Guatemalan and Honduras birds, being 3.5 mm. In South American birds a considerable reduction occurs—almost to the level of the extreme northern specimens.

The variation in the white of the fourth pair of tail feathers is peculiar. From Arizona to Central Mexico there is a slight but gradual reduction in area—from 16.1 in the north to 13.9 in the latter locality. The Guatemalan, Nicaraguan and Venezuelan birds show a sudden increase—to 25.8, 30.6 and 36.2 mm. respectively, showing that in this pair of rectrices the color variation is far more active and more significant of distribution, and hence climatal effect, than in the outer, or sixth, pair. The size of the white spots in the Brazilian specimen, 24.8 mm., is interesting when we see how closely it approaches the Guatemalan birds, and consider that the two localities, Guatemala and Bahia, Brazil, are about 15 degrees distant from the equator, the one north, the other south, latitude.

The status of variation in the fourth pair is duplicated in the third pair of rectrices, and is even more pronounced, as reference to Table IV will show. The first important fact (as demonstrated by the lessened number of specimens in this Table) is that in two-thirds of the doves from Arizona to Mexico the white tips of the third pair of tail feathers are entirely absent, the proximal brown color extending unbroken to the very extremity of the feathers. Even where the white color is present it is but a terminal fringe, varying in average area from 1 mm. to 2.9 mm. From Guatemala southward, to and including the

*For the use of fifty-six skins of *Scardafella*, I am indebted to the American Museum of Natural History, and for the type specimen of *S. i. dialeucos* to Mr. Outram Bangs.

TABLE II.

Geographical variation in the White Tip of Sixth Pair of Rectrices of *Scardafella*—Outer Pair.

Locality	*Number of Specimens*	*Number of Feathers*	*A X*	*B X*	*C X*	*D X*	*E X*	*Average Area*
Arizona	10	13	52.5	42.3	32.8	33.6	34.8	39.2
Texas	12	22	54.2	43.9	39.1	38.2	33.5	41.7
North Mexico	12	21	57.1	41.5	35.5	35	31.5	40.1
West Mexico	10	17	52	42.6	36.2	32.2	49.3	42.4
Guatemala	2	4	60	47.7	42.2	41.5	37.2	45.7
Honduras and Nicaragua	1	1	62	49	46	45	44	49.2
Venezuela	9	13	49.5	43.1	38.6	40.2	42.2	42.7
Brazil	1	2	49	42.5	36.5	33.5	33.5	39

TABLE III.

Geographical variation of the White Tip of Fourth Pair of Rectrices of *Scardafella.*

Locality	*Number of Specimens*	*Number of Feathers*	*A X*	*B X*	*C X*	*D X*	*E X*	*Average Area*
Arizona	10	14	20.6	18.6	16.3	16	9.2	16.1
Texas	12	21	18	14	15.5	18	12.7	15.6
North Mexico	12	22	16.8	14.5	16.5	15.8	8.5	14.4
West Mexico	10	13	14.2	13	15.8	16.6	10	13.9
Guatemala	2	4	22	25.5	28.7	28.5	24.7	25.8
Honduras and Nicaragua	1	2	33.5	27.5	32.5	35.5	24	30.6
Venezuela	9	13	36.2	35.5	36	37.3	36	36.2
Brazil	1	2	25	29.5	24	22.5	23	24.8

TABLE IV.

Geographical variation in the White Tip of Third Pair of Rectrices of *Scardafella.*

Locality	*Number of Specimens*	*Number of Feathers*	*A X*	*B X*	*C X*	*D X*	*E X*	*Average Area*
Arizona	4	8	5.5	3.1	2.1	2.6	1.2	2.9
Texas	5	10	3.7	2.9	.7	.8	1.9	1
North Mexico	1	2	6	0	0	0	0	1.2
West Mexico	5	10	4.7	0	0	2.2	1.4	1.6
Guatemala	2	4	10	5.2	7.5	6.7	5.5	6.9
Honduras and Nicaragua	1	2	8	5.5	4.5	10	1	5.8
Venezuela	9	17	8	8.5	8	8.1	9.5	8.4
Brazil	1	2	8.5	0	0	5	5	3.7

FIG. 4. Tail Feathers of a melanistic *Scardafella inca*, showing extreme incroachment of the dark pigment, at the tips as well as at the bases of the feathers.

Brazilian specimen, 100 per cent. of the doves show white-tipped third rectrices, and, allowing for individual variation in the Nicaraguan specimen, the ratio of variation is the same as in the fourth pair of feathers; the Venezuelan birds showing the greatest amount, and the Brazilian specimen a reduction approximating the area of the Honduras doves.

As the extreme development of white we find the second pair of rectrices distinctly tipped in several of the Venezuelan specimens, and the dove described from Margarita Island by Dr. Richmond is said to have white on the terminal parts of five pairs, the central tail feathers alone appearing solid brown.

With all this general uniformity of result, the great individual variation should not be lost sight of. In two birds from the same locality, collected within a few days of each other, the variation may be extreme. In one the demarcation of dark brown and white in the rectrices is sharp and clear cut; in the other the colors merge so insensibly into one another that it is difficult to tell where to put the millimeter measure.

Of the entire body plumage, the under tail coverts perhaps show this individual variation to the greatest degree. If there is a distinct terminal mark of black, the feather is apt to be white elsewhere, but the reduction or absence of this mark is often accompanied by an infusion of pale dirty-brown from the base of the rhachis, extending along the shaft line and sometimes discoloring two-thirds or more of the whole vane. This condition, however, is confined to the more northern birds, the colors of the South American doves being remarkably distinct and clear-cut.

In the Arizona and Texas birds there is also considerable variation in the pigmentation of the right and left wing and tail feathers, while in the tropical specimens almost perfect bilateral symmetry is found.

B—The Effect of Humidity on Scardafella inca (*Less.*).

When typical specimens of *Scardafella inca*—the Inca or Scaly Dove, from Arizona or Mexico are confined in the humid atmosphere for at least six months before the annual fall moult, there is a noticeable change in the new feathers; a slight increase in the amount and intensity of the dark tips, uniformly over the whole body, and a slight blackening of the primaries and rectrices. One individual, even at this first moult, shows a condition adumbrative of the whitened wing coverts which are so conspicuous a feature of the next moult. This bird closely resembles the *Scardafella inca dialeucos* type. At the second fall

moult this general darkening is much more noticeable, and correlated with it there is considerable reduction of the rufous on the primaries and on the lining of the wings. The greater wing coverts are very light, the outer vanes appearing almost pure white in contrast with the adjacent areas of black and dark brown.

Although the considerable individual variation, as shown in greater or less reaction to the humid atmosphere, is very noticeable even in the few specimens upon which I have been able to experiment, yet the general average appearance of this moult under these conditions is not distinguishable from that of a wild bird in the typical plumage of *Scardafella ridgwayi.*

The rose or lilac ground color of the upper anterior part of the plumage remains unchanged, until, in succeeding moults, it is totally obscured by the encroaching melanin pigment; the white of the lower breast remains clear white to the last; the suffusion of pink over the breast loses none of its intensity until completely concealed by the black. In the final stage, attained in the fourth or fifth moults, the chestnut on all the primaries has completely disappeared; the breast feathers, secondaries and even the greater coverts have lost all trace of white, although, as we noticed above, the coverts had become noticeably whiter at the second moult. The last white to remain is a spattering upon the longest under tail coverts and upon the three outer rectrices.

TABLE V.

Primary Change of Coloration Area of *Scardafella* under Humidity.

	At End of Third Annual Month, Jan. 28	*First Induced Monthly Renewal Feb. 25*	*Second Induced Monthly Renewal Mar. 27*	*Average Increase of Area*
Outer Right Primary......	38		41.6	3.6
Second Right Primary....	37.4	37.8	39.2	1.8
Third Right Primary......	36	38	39.2	3.2
Sixth or Outer Rectrices..	32.8		33.3	.5
Fifth Rectrices.............	24		29.4	5.4

Table V gives the average areas of the black on the primary tips and of the white on the three outer pairs of rectrices of a bird from Mexico which, under experimentation, had completed the normal third annual moult. It will be seen that the area of the black outer primary patch is slightly larger than in the wild Brazilian bird (Table I). The white on the outer rectrice of

the captive dove shows an extreme individual variation in the direction of reduction, no greater, however, than exists among wild individuals. The chief interest of Table V lies in the comparison of the measurements of the feathers which came in after those first recorded were pulled out. Three such successively induced renewals of feathers show a regular change in extension of color area—in the case of this bird of the third regular moult, an *increase,* both of the primary black patch and of the rectrice white. Taking the outer primary we may judge of the ratio of increase between the regular annual moults, and the induced monthly feather renewals, by the following comparison:

	Wild Bird from North Mexico	*At 3rd Annual Moult of Captive Dove*	*Feather Renewal One Month Later*
Area of Outer Primary Patch	25.9	38	41.6
Average Increase		4	3.6

This indicates that the increase of pigment in one month in an artificially induced renewal of the feathers is about the same as that occurring in a feather which comes in as a result of the normal annual moult. If this comparative scale of increase of melanin should hold good, plumage as black as in the sixth year individual about to be mentioned could be obtained in almost the same number of months by monthly feather renewals. No test of this has yet been made.

Table VI relates to a dove which has completed six regular annual moults in the humid atmosphere, and has become almost entirely black. At the examination of January 28th, a very faint trace of rufous was observable near the center of the third from outer primary, but in the new feathers observed March 27th, all

TABLE VI.

Secondary Change of Coloration Area of *Scardafella* under Humidity.

	At End of Sixth Annual Moult, Jan. 28	*Succeeding Induced Feather Renewal, Mar. 27*	*Average Decrease of Area*
Outer Right Rectrice	29.4	28.4	1
Fifth Right Rectrice	25	23.8	1.2
Fourth Right Rectrice	11.2	4.6	6.6

trace of this color had disappeared. Hence data for comparison is confined to the rectrices. Besides the three outer pairs of these feathers, no white was left on the dove except an irregular whitish-gray blotch on the longest left under tail covert.

The most interesting fact brought out by the monthly feather renewal of this black dove is the *reduction* of the white on the rectrices, instead of an *increase*, as was the case with the dove in the third moult.*

The most logical explanation would appear to be that excessive humidity causes, not only an increase but, especially during the first few moults, a concentration of the melanin—resulting in a segregation of the black and white and consequently an increase in area of the latter. This condition is at least paralleled in wild Arizona and Venezuelan specimens (*vide* Table I). If, however, the humidity continues to act, and here we get beyond the stage of any wild *Scardafella,* a point is reached where further concentration of melanin is impossible, and the overproduction of granules is forced into the surrounding epidermal structures. (Fig. 4.)

From now on a gradual *reduction,* (Table VI), of the white area takes place until the dark hue is everywhere predominant.

It may here be stated that in a number of cases measurements were made when the feathers had just broken from their sheaths, and again, eleven months later, just before the annual moult, and no change was apparent. *This eliminates from these experiments any theory of increase of melanin without moult.*

I have elsewhere recorded the fact† that the pigmentation of the choroid coat of the eye is, at least in owls, correlated with the pigmentation of the plumage, the choroid of a dusky horned owl being very strongly pigmented as contrasted with the all but absence of pigment in a snowy owl. The optical fundus of a small dove such as *Scardafella* is very difficult to observe, and thus far I have been able to make out only the grosser details. But in my completely melanized specimen the great increase of pigment over a normally colored *Scardafella inca* is very noticeable, and is interesting as showing that the pigmentation of this part of the eye is as plastic as that of the plumage. It is, however, only what we should expect when we recall their identity of origin; the feathers being epidermal structures arising from an induration of epidermal papillae containing a vascular core, while

* Fig. 4 shows that this restriction of the white of the rectrices is not only from the proximal part of the feathers, but at the tips where there has appeared an area of encroaching black.

† "Owls of the Neartic Region," Eleventh Ann. Rep. N. Y. Zool. Soc.

the epithelial pigment of the choroid is as truly epidermal, tracing its derivation, in the embryo, from the involuted epiblast of the medullary canal.

With the sixth moult, experiments have for the present ended, but the blackest dove now in the collection exhibits an interesting condition which may, in future work, prove as significant as it was unexpected. In wild specimens of *Scardafella inca* there appears to be no trace whatever of any iridescence or metallic tints, the darker tips of the feathers being a dull and lifeless brown. In the Venezuelan *S. ridgwayi* the largest dark-tipped feathers show, in a very favorable light, a trace of dull greenish or bluish sheen.

In the darkest bird under experiment, this metallic color is strongly developed, and in a most interesting way. The feathers of the lower parts show little iridescence, and this of a bronzy character, but above, the plumage is as iridescent as that of any East Indian fruit pigeon. The entire back and rump are similar in hue, each feather having a broad tip of iridescent bronze, while the remaining exposed part of the feather is of a brilliant green, this tint extending down along the rhachis as a shaft stripe, a little way into the distal bronze portion. The primaries and outer secondaries are dull black, but on the inner secondaries, coverts and scapulars the most brilliant iridescence is found. On some of the feathers blue and green seem arranged in cross bars, but, on the whole, the metallic coloring is irregular, the entire feather changing in color as the angle of incidence of the light is changed. This alar distribution of iridescence becomes significant when we consider the occurrence of metallic color in the plumage of many genera of doves—some rather closely related to *Scardafella* and others separated by considerable structural differences.

The rather closely related genera *Columbula* and *Chamaepelia*—ground doves of the Neotropical Region—are ornamented with metallic colors on the wing coverts; in the first mentioned forming a band of steel blue on the lesser coverts, and in *Chamaepelia* being arranged as a number of spots and blotches, both on wing coverts and inner secondaries. These spots are of various colors, as bronze in one species and purplish-green in another. In a future paper I shall discuss variation in the genus *Chamaepelia* and the effect of artificially changed conditions of environment on these metallic patches; but here I mention them only to show the tendency, in certain groups of doves, to iridescence on the wing coverts. In our northern mourning dove, *Zenaidura macroura*, the wing coverts exhibit dark spots which are glossy

but hardly metallic. As the opposite extreme, in an otherwise rather dull-hued bird, I may mention *Ocyphaps lophotes,* the Australian crested pigeon, in which the greater wing coverts are a shining, bronzy green, while the inner secondaries glow with the richest iridescence—changing from purple to blue.

Until my observations have been supplemented by microscopic work I shall hazard no speculations as to whether, in *Scardafella,* the continued effect of humidity brings about an actual change of structure in the barbs of the feathers, when the dull-brown or white color of the wing coverts gives place later, in the same individual, to metallic tints. If so, according to Gadow's theory, this would be iridescence by refraction. On the other hand, iridescence may result merely from the abnormal abundance and extreme concentration of spherical melanin granules producing the effect of Newton's rings, or thin-plate interference colors. The latter would seem the more probable theory, apparently supported by the careful work of Strong on the domestic pigeon. I have not yet had the opportunity of verifying this in the case of *Scardafella.*

C—Summary of the Effects of Humidity.

1. When typical specimens of *Scardafella inca* are confined in a superhumid atmosphere, a radical change in the pigmentation of the plumage takes place with each succeeding annual moult.
2. A change, apparently similar in extent and direction, results from an artificially induced monthly renewal of the feathers.
3. The change at the first annual moult brings the bird close to the *Scardafella inca dialeucos* type.
4. At the second annual moult, the plumage approximates either the Brazilian type or the typical *S. ridgwayi,* the succeeding changes being unrepresented by wild species of the genus.
5. Intrinsically the change is at first a segregation and intensification of the melanin, resulting in a clearing up and extension of the white or whitish areas.
6. A period of equilibrium later ensues, until the increase of melanin is such that it begins to encroach upon the white areas, this continuing until all trace of white has disappeared.
7. Coincident with this intense blackening of the plumage part of the epidermis, occurs an increase of pigment of the choroid coat of the eye.

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FIG. 5. Ventral View of (a) Typical wild *Scardafella inca*; (b) Type specimen of *S. i. dialeucos*; (c) Typical wild *Scardafella* from Brazil; (d) Typical wild *S. ridgwayi* from Venezuela; (e) *S. inca* after three moults in a superhumid atmosphere.

8. When the concentration of the melanin has reached a certain stage, a change in color occurs, from dull dark brown or black to a brilliant iridescent bronze or green.

9. This iridescence reaches its highest development on the wing coverts and inner secondaries, where, in many genera of tropical and sub-tropical doves, iridescence most often occurs.

10. All these changes take place by continuous variations, and there is no change of color without moult.

D—Significance in Respect to Direction of Evolution.

The increase of pigment in a single individual under humidity during a comparatively short period of time, and the subsequent correlated development of metallic tints, assume a new importance when we consider that, in these experiments at least, mutation and natural selection have no place.

In a recent paper embodying some interesting comparisons of many wild species of doves and pigeons, Prof. C. O. Whitman advances the theory that the various gradations of color patterns, such as those on the wing coverts, are hints of closer or more remote biological relationship, and the apparent directive progress of the character he explains by orthogenetic variation, affected to a certain extent by natural selection, but not by mutation. He says: "If a *designer* sets limits to variation in order to reach a definite end, the direction of events is teleological; but if organization and the laws of development exclude some lines of variation and favor others, there is certainly nothing supernatural in this and nothing which is incompatible with natural selection. Natural selection may enter at any stage of orthogenetic variation, preserve and modify in various directions the result over which it may have had no previous control."

Setting aside discussion of the orthogenetic theory itself, we find that Prof. Whitman is able to offer in regard to the actual transition of one stage of coloring to another, evidence only from comparison of wild species, or from young and adults of some one species. He says: "But is there any direct proof that the transformation is actually making progress to-day? May not these transitional steps go on appearing generation after generation, without ever making any permanent progress? We have to concede that we can not follow the processes that reveal themselves in steps. We can at most only see what is done—not the doing. We are entirely in the dark as to the time required to carry the change through a single row of feathers."

Perhaps the most interesting part of Prof. Whitman's paper is that relating to eight years' experimental breeding of domestic pigeons. In the offspring of checkered birds, by careful selection, birds with fewer checkers were produced, these checkers gradually merging into three and two bars, and at last into one, following which came total obliteration of dark color on the wings. It was found impossible to reverse the process, that is, to obtain doves of the checkered type from typically barred birds. Hence the author assumes that "the direction of evolution can never be reversed."

In comparing these statements with the results which I have obtained with doves under the influence of humidity, there is one fact of which we must never lose sight—perhaps the most important factor with which we shall have to deal, when future experiment enables us to stand on firmer ground. This is, whether we are dealing with *acquired* or with *congenital* characters. In the case of the individual *Scardafella* doves there is certainty that the seeming atavistic characters are *acquired.*

Nine genera of *Columbiformes* are found in the United States, one of which, *Ectopistes*—the passenger pigeon—is autochthonous, at least in its present distribution, while *Zenaidura* —the mourning dove—extends southward only as far as Panama. The remaining seven are highly developed in the Neotropical Region, hence we may be reasonably certain that the Columbine element in the North American fauna is of tropical origin.

This would indicate that those forms of doves and pigeons which barely extend over our southern border have been derived, more or less recently, from tropical types. Accepting this as a fact, then in reproducing a tropical atmospheric environment for our *Scardafella inca* and by this means rehabilitating it in its ancestral plumage, we apparently demonstrate an exception to the assertion of Prof. Whitman that "the direction of evolution can never be reversed."

On the other hand, the *modus operandi* of this atavistic change seems to support that author's orthogenetic theory, in so far as the recapitulation follows along the same lines (1) as in related genera of doves, and (2) in the identity of the details of the change in several individuals. This indicates that this humidity-induced variation is neither fortuitous nor directionless.

Interesting and significant as the results are, they but open up innumerable new vistas of unexplored fields. If the melanic doves were bred, would there be any trace of inheritance of these

acquired color characters? If subjected to an environment of extreme dryness would *Scardafella ridgwayi* assume the plumage of *S. inca?* Would other melanizing factors than humidity, such as hemp food, bring about similarly orthogenetic series of changes?* Is *Scardafella* especially plastic in response to experimentation, or does this plasticity reflect very recent variation in the feral state? What would be the effect of applying these conditions before the adult plumage is acquired?

Have we in these unexpectedly radical changes of plumage under humidity any hint or clue to the annual changes of many migratory birds, such as the male scarlet tanager, indigo bunting and bobolink, which assume brighter colors after a winter in the humid tropics? If so, why are the females immune from such influence? Considering Prof. Whitman's law, under these conditions of experimentation, can the direction of evolution ever be *anticipated?* These and a hundred other important aspects of the problem all await solution.

In regard to the all-important question of the inheritance of somatic changes produced by external factors, we have for comparison the affirmative facts given by Fischer, who produced moths of dark colors by exposure to a low temperature and reports that the offspring of two of these moths were also dark; and the negative results of Tower, who after experiment upon ten lineal generations of *Leptinotarsa* declares that "it is clearly demonstrated that the somatic variations in color are not inherited, but that they are fluctuating, transient, and due solely to environmental stimuli which accelerate or retard color development." Tower explains the affirmative result by the apparently logical reasoning that during the period of experimentation in the case of the lepidopterous insects, the germ cells were in the more sensitive stages and hence were directly affected by the stimulus of cold, this being not the case in his own experiments. If this is true, we have yet to await the demonstration of the inheritance of a true acquired character—a phenomenon which will doubtless never be forthcoming.

E—Correlation with Natural Selection.

The question will at once be raised by some, that my experiments, as far as they go, indicate that natural selection has little or nothing to do with such phenomena as protective colora-

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*As far as my experience goes, a diet of hemp produces in *Scardafella* an irregular blotchy melanism, very different from that induced by humidity, but this is based on only one individual.

tion and mimicry. But I think this is not the case. Even among the four or five individual doves, upon which the experiments were carried out, there is a noticeable variation in the readiness of response to the unusual conditions; in the course of the first two moults one individual becoming melanized to a greater extent than the other doves.

If Arctic animals are white *solely* because of physiological reaction of the pigment-producing tissues to cold or other environmental factors, why should the musk ox (*Ovibos*) and raven (*Corvus*) be such conspicuous exceptions to all the other terrestrial vertebrates of those northernmost regions? We may correlate with this, the fact that, owing to their food and powers of defence, these two creatures have least need of either protective or aggressive coloration.

If natural selection can not and does not sometimes entirely annul this physiological reaction to temperature and humidity, why does the snowy owl not change in summer like the ptarmigan? and why does the mink retain its dark pelage throughout the year, while its near relative, the northern weasel, becomes almost wholly white? It is said that Arctic animals when brought into warmer regions sometimes become darker in hue, but, as far as I know, the reverse has not been observed.

The sporadic appearance or artificial inducing of melanism *in a single individual* under humidity may be explained, and probably correctly, as merely the result of intensified action of the pigment-producing enzyme or unorganized ferment. But this becomes of profound interest and importance to the evolutionist when we consider it as one, among other widespread factors in the production of new races and species. The fact that such radical changes in appearance can be brought about—not only by the well-known method of careful selection through many generations, and with definite exclusion of the very improbable theory of the change of color in the plumage without moult—but by comparatively rapid, cumulative, apparently orthogenetic, acquired variations, will cause many of us to consider a revision of our ideas as to the length of time necessary for the formation of new races and species, when these are based on color characters alone. And this without the aid of De Vries' theory of mutation by one profound saltation, whatever the part this may have played under other, as yet imperfectly understood, conditions.

The absence heretofore of all evidence of such rapid, continuous variation as shown by these experiments, has naturally led to statements such as the following: "The gradual evolution

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FIG. 6. Side view of *Scardafella* doves shown on page 31.

of a permanent change of color, such as marks geographical races or representative species for example, must obviously be due to the long-continued action of the environing conditions upon the whole organism."

F—Correlation with Taxonomy.

Up to the present time, considerations of ontogenetic, as compared with phylogenetic characters or "species" have been of little import to the taxonomist, considered strictly as the delineator of living species. His business is to perfect, as nearly as possible, the forging of the nomenclatural handle by means of which we may grasp present conditions of life on the earth, and which enables us intelligently to communicate to one another the results of our studies.

To speak in hyperbole—it has not directly concerned him whether the color of *Scardafella* is as fleeting as the life cycle of a single feather, or as permanent as the power of flight in these doves. Through the processes of evolution both color and flight were acquired in past time—whether at the preceding moult or during the Jurassic Age; whether by a rapid chemico-physical process or by gradual synthetic variation through geological ages—has made no difference in the delineation of species living on the earth to-day. Nevertheless, in the words of Dr. Merriam, "a knowledge of the *degree of difference* between related forms is infinitely more important than a knowledge of whether or not the intermediate links connecting such forms happen to be living or extinct."

Regarding the characters of ontogenetic species Dr. Jordan writes: "Perhaps our ornithologists will some day test their species and subspecies by a test of the permanence of this class of characters. No doubt we should drop from the systematic lists all forms which may prove to be merely ontogenetic, all whose traits are not fixed in heredity." In answer to this Dr. Allen says, "any attempt to distinguish ontogenetic species from other species or subspecies tends to confusion of ideas rather than to any useful discriminations."

Of course, at best, only a small proportion of living forms could be so successfully subjected to transplanting or to experimental conditions, that their exact status in an onto-phylogenetic classification could be ascertained. Nomenclature is avowedly artificial and imperfect: its permanence, dependent on the existence of the historical period of the human race; its advance, on the increase of knowledge. When the new science of experi-

mental biology has developed to a point where it can clearly account for, if not indeed anticipate, results of experiment upon wild creatures, there seems no more objection to admitting such evidence than that obtained through embryology, anatomy or palaeontology. The development of birds from a reptile-like type is not the less certain because we know of only two specimens of Archaeopteryx; and, although comparatively few types of living organisms can be experimentally tested, the resultant evidence, when we can clearly interpret it, is of none the less value.

The crucial point seems to be that, while we should use this evidence to the utmost in unraveling the intricate processes of evolution, and in understanding the past history of the wild living forms, or as we call them species and subspecies, as now defined—yet to alter our entire list of species, discarding all forms—which are ontogenetically interchangeable under experimentation or in a new environment, by analysis or synthesis as the case may be, is no more reasonable than to discard a genus of living creatures because palaeontology reveals more delicate gradations between it and a second living group—isolated by the present conditions of life.

If I take an individual *inca* which, under certain conditions, has changed to a darker form, more extreme than *ridgwayi,* and apply to it the term *nigra,* I may claim that it represents a good ontogenetic species, isolated by moult from any other species. As long as the conditions remain the same, my new species remains unchanged, perhaps for years, but if it moults into a still blacker form, the status of *nigra* would revert, theoretically, to the condition of an extinct fossil link; but practically, this distinction would be inimical to the usefulness of classification. It would mean recognizing one of the past moults of *the individual* as a prototype or ancestral connecting link!

The boast of our scientific nomenclature is that it is as near the natural order of evolution as possible and yet remain a help to working naturalists. When this most important function is imperilled by the naming of innumerable variations within a narrow field, the more conservative biologists rightly protest. The same would result if, in the case of *Scardafella,* having transmuted an individual *inca* into *ridgwayi,* and thus proving the differentiation to rest merely upon ontogenetic characters, the name *ridgwayi* should be stricken from our lists, regardless of the fact that there is apparently a geographical hiatus between the two forms in a wild state. Differences between the two species in habits, nidification, courtship or notes, could not be expressed were both swamped under one name.

Theoretically, and to the evolutionist in the widest sense of the word, (for whose use nomenclature, to all intents and purposes, solely exists), the results of experimental biology are of greatest importance, but the forms thus artificially produced should no more be added to the lists of natural species than should the brahmas and plymouth rock fowls of our barnyards. As in so many scientific questions there is a border-land difficult to define, and in this case it consists of the forms transplanted by man in more or less distant times, which have developed new characteristics (as in the Porto Santo rabbits). In my opinion, none of these should be placed on our lists without being stigmatized as to the human influence involved.

To those of us who are primarily students of the broader aspects of evolution, the results of experimental biology appear most valuable in giving clearer insight into the conception of the ideal and only *natural* classification—one arranged in the three planes of space.

G—Correlation with Organic Selection.

Any correlation of the results outlined in the present paper with the various theories of evolution must be tentative in the present state of our knowledge. Keeping this in mind, the following explanation appears among the most logical and probable.

The results of the effects of humidity are open to the following interpretations: (1), they may reflect a reversal of evolutional variation along the line of least resistance, from *inca* through *dialeucos* to *ridgwayi* and beyond; (2), they may indicate an advance in evolution, paralleling the condition found in wild tropical types; (3), they may represent merely indefinite fortuitous variation, brought about by a change in the environment. Whichever we choose for the present as the most reasonable working hypothesis, it seems to me that we have an excellent argument in support of the theory of organic selection.

We know that melanin is a non-ferrugineous non-hematogenous intrinsic pigment, absorbing the violet rays which, at least in ourselves, are particularly irritating to the skin. If the same phenomenon holds true of birds, an increase of melanin in the epidermal structures would certainly prove of advantage in a hot moist climate, and might thus be considered an adaptive structural response.

In the case of *Scardafella* we see an instance of remarkably rapid physiological reaction to a radical change of the environment. In a state of nature such a change might be imagined as

taking place under conditions approximating those of the formation of the Salton Sea, in the Colorado desert in southern California, where the sudden appearance of a large body of water in an arid region might be accompanied by a considerable increase in the relative humidity. If any change in color in the plumage of the local species of dove should prove of adaptive value, in influencing even to a slight degree the vitality of the birds, the species would at once benefit. Natural selection would exert an important influence in the elimination of those with less plastic pigment-forming enzymes, or it might operate in an antithetical way by raptorial elimination of the darkest, most conspicuous, individuals. Be this as it may, we can be reasonably certain that this ontogenetic modification is only somatic, and that the offspring would acquire the dark color anew only with the first few moults. Until some of the problems offered by *Scardafella,* mentioned on page 33, have been solved, we have no means of telling how soon or in what manner this modification would become congenital; or, in other words, would be transferred from an acquired to an inherited character.

But this is not necessary to the present argument, that, in the *Scardafella* color modification, organic selection finds strong support. If the new character, ontogenetically acquired, is in any way adaptive, it might easily be the means of preserving the species until phylogenetic variation had impressed it upon the race.

That we have much to learn concerning these greatly disputed classes of variation is shown by another phase of this very experiment. We have seen that the specific and apparently permanent color distinction between *S. inca* and *S. ridgwayi* is, in reality, so plastic that a year or two of superhumidity will annul it. Thus two species widely separated by a geographical hiatus may actually be differentiated by the most evanescent of acquired characters. So, while theoretically explainable by organic selection, yet we see that a character, which few evolutionists would have considered apart from regular inherited, specific characters, might, after we know not how many years and generations, still prove to be of the most superficial and transient nature.

Bearing in mind the Porto Santo rabbits and the probably considerable time during which *Scardafella* has inhabited Mexico, we can easily see that an ephemeral, acquired, yet adaptive character, might render life possible in a region otherwise untenable, through a sufficiently long period of time for congenital variation plus natural selection to bring about skeletal and other modifications of generic, if not indeed of family, importance.

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Fig. 11. Flock of Eleven Hoatzins on the Abary River.

A CONTRIBUTION TO THE ECOLOGY OF THE ADULT HOATZIN.

Ecology of the Hoatzin.

PART I—INTRODUCTION.

The strangeness of life and structure of this bird have made it classic in the annals of ornithology, and because of this claim upon our interest I offer the present article as a résumé of our present knowledge of the habits of the adult Hoatzin. We are still ignorant of a considerable part of its life history, although there is small excuse for this, as the bird is sedentary, abundant wherever found, and tame to an absurd degree.

I have had two brief opportunities for observing this species in life, once in March, 1908, on the Guarapiche River in northeastern Venezuela, and again in April, 1909, on the Abary River, British Guiana. On neither occasion were young birds to be found, so my notes refer solely to the adults.

Although it is not my intention to discuss the anatomy of the Hoatzin, mention may be made of certain peculiarities, which exert an important influence upon its habits and activities.

The crop of this bird is unique in having assumed the structure and importance of the gizzard in other birds. It has increased greatly in size, measuring, when well filled with food, about two and a half inches in diameter. The walls, instead of

being flabby and glandular, are thick and muscular. This increase in the size of an organ situated far forward in the body has resulted in a reduction of the front part of the keel of the sternum, a condition unique among birds. In reducing the area of attachment for the pectoral muscles, this change has radically affected the power of flight.

In spite of this specialization, there is no doubt that the Hoatzin is an extremely ancient and isolated type, and it has very properly been set aside in a separate Order by itself—Opisthocomiformes (43). Combining, as it does, the characters of several Orders, it is impossible to indicate its correct position in a linear classification. In such artificial, two-plane, genealogical trees, it has been variously placed between the game birds and the rails; between the pigeons and the rails; while it has certain affinities with the plantain-eaters, and the vestigial claw on the third digit links it with the primitive Archaeopteryx.

Another claim to a primitive condition is found in the quadrupedal habits of the young. These, by means of unusually developed fore limb and fingers, and external claws on the first and second fingers, are able to climb actively about the bushes. They also swim and dive well.

Part II—History.

More than two hundred and fifty years ago Hernandez, in his *Nova Plantarum, Animalium et Mineralium Mexicanorum Historia* (22), makes the first authentic mention of the Hoatzin, writing in Latin as follows:

"The Hoatzin,—a bird uttering a curious note, sounding like its name.

"This is a bird of about the size of an Indian fowl. Its beak is curved; its breast shades from white to buff; its wings and tail are spotted with white at intervals of a thumb's length; the back of the upper part of its neck is yellow, shading into blackish on both sides and sometimes extending as far as the beak and eyes; the claws are black and the legs blackish. The bird bears a sturdy crest of feathers, varying from white to yellowish, the back of each feather, however, being black. The bird subsists upon snakes. It has a powerful voice which resembles a howling or wailing sound. It is heard in the autumn and is held inauspicious by the natives.

"The bones of this bird relieve the pain of wounds in any part of the human body; the odor of the plumage restores hope to those who, from disease, are steadily wasting away. The ashes

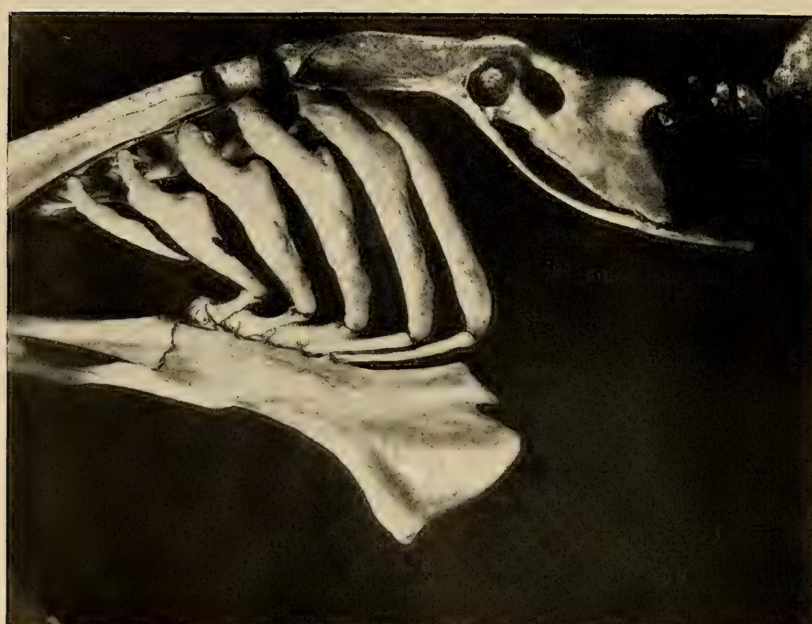

Fig. 7. Breast-bone of Hoatzin.

of the feathers when devoured relieve the Gallic sickness, acting in a wonderful manner.

"The bird lives in warm regions, such as Yauhtepeceusis, generally establishing itself in trees growing along the banks of the streams, where we, having observed it, captured it, and making a drawing of it, kept it alive."

With the exception of the description, which is fairly accurate, this quotation is interesting chiefly because of its characteristically medieval superstition.

One hundred years after the account of Hernandez, Brisson (11) wrote a vague and plagiarized description of the New World bird which he called Le Hocco Brun de Mexique (*Crax fuscus mexicanus*). He said:

"It is nearly as large as a female Turkey. Its head bears a crest composed of feathers which are yellowish-white above and black below. The sides of the head, the upper part of the neck and back are reddish-brown. The breast is yellowish-white. The wings and tail are varied with white and yellow, and that by spots of a thumb's length. The feet are brown; and the claws black. It feeds on serpents. It is found in Mexico, and chiefly in the hottest parts. It perches on the trees which are found along the rivers."

The final sentence is admirable; but as the bird is a vegetarian and is not found in Mexico, and as Brisson seemed rather color blind, little can be said as to the remainder of the quotation, which I offer merely from the interest attaching to very early accounts.

As in the above instance, the inaccuracies of the pioneer ornithologist Hernandez have been repeated, and, indeed, enlarged upon by succeeding authors. Thus Latham (26) twenty-three years later, informs us that the "Crested Pheasant" inhabits "Mexico and parts adjacent, where it feeds on snakes; makes a howling kind of noise, and is found in trees near rivers; is accounted an unlucky bird. Met with chiefly in the autumn, and is said to pronounce a sound not unlike the word 'Hoactzin.' We learn from others that it may be domesticated, and is seen in that state among the natives; and further that it feeds on ants, worms and other insects, as well as snakes."

In 1819, about sixty years after Brisson's account, Stephens (47) vouchsafes the following information concerning the "Hoatzin Serpent-Eater":

"It inhabits Guiana, and is found on trees near rivers; its food consists of grains and seeds; it will also eat insects and serpents; it has a howling, disagreeable note; its flesh has a very

disagreeable smell (probably caused by the quality of its food) and is consequently not eaten, but is used by the fishermen to catch certain fishes."

Even the writings of recent observers, on the spot, with every opportunity for good observation, are in some instances totally misleading. For example, Penard (34) tells us that Hoatzins run rapidly on the ground, swim well, and "leven in groote troepen van honderden individuen."

Part III—Name.

Müller (28) called the bird *Phasianus hoazin,* and although it was soon removed from that genus, his specific name still stands accepted. The name hoatzin, hoazin or hoactzin, as it is variously spelled, refers to Hernandez' (22) account, of which Buffon (13) says:

"Its voice is very strong, and it is less a cry than a howl. It is said that it pronounces its name (Hoatzin) apparently in a sad and mournful tone. It is no longer necessary to make it pass with the common people for a bird of ill omen; and since everywhere a great deal of power is assigned to that which is feared, the same people have thought to find in it remedies for the gravest maladies. But it is not said that they feed themselves on it. They abstain from it in fact, perhaps as a result of the same fear, or because of a repugnance founded on the fact that it makes its ordinary food of serpents. It stays usually in the great forests, perched on the trees along the water, for watching and surprising these reptiles. It is found in the hottest parts of Mexico. Hernandez adds that it appears in autumn, so that it is a migratory bird. Mr. Aublet assures me that these birds become tame; that they are sometimes seen in captivity in the houses of the Indians, and that Francois called them Peafowl. They feed their young on ants, worms and other insects."

Much of the charm of this wholly inaccurate and altogether delightful account is lost in the translation from Buffon's native tongue.

The present generic name *Opisthocomus* was given by Stephens (47), referring to the long, waving crest; ὀπισ θόκομος, wearing the hair long behind, or, literally, having hair behind. (ὄπισ θεν, behind, + κόμπ, the hair).

Ignoring the various bizarre appellations given to this species by writers of the last century, we may review the common names in use to-day.

Fig. 8. Half-grown Hoatzin, Showing Claws on Thumb and First Finger.

Quelch (38) writes twenty years ago "The Hoatzin is known in British Guiana by the various names 'Anna,' 'Hanna,' 'Canje or Stinking Pheasant,' and 'Governor Battenberg's Turkeys'; but in the districts where it is found, the name 'Hannah' is the one most commonly used." In a recent trip to the above mentioned colony, I heard only the name "Canje Pheasant" used, although I discussed the subject with people of many classes.

Among the Portuguese of Brazil the Hoatzin is called *Cigana,* meaning gypsy, and *Catingueiro,* signifying odor of the negro. The Dutch of Cayenne speak of these birds as *Canje Fazanten,* while the more euphonious name of the Venezuelans is *Guacharacas de Aqua.* They also call it *Chinchena,* while in Bolivia the Hoatzin is known as *"Loco,"* or crazy bird.

Part IV—Distribution.

The little we know of its distribution shows that the Hoatzin is as remarkable in this respect as in other phases of its life history. Sharpe (45) gives its range as follows: Amazonia, Guiana, Colombia, Ecuador, Peru and Bolivia. This is very misleading, however, for certain factors enter into the question of inhabitable territory which require more detailed reference.

Penard (34) writing of the birds of Dutch Guiana gives as the local distribution of the Hoatzin, "Wouden en terreinen waar *Arum arborescens* groeit." This is certainly not true as regards

Fig. 9. Distribution of the Hoatzin, as Far as Known.

British Guiana. The great heart-shaped leaves of that Arum are seen along the lower reaches of every coastal river, yet the Hoatzins are confined to three streams, two of which are little more than creeks, in the extreme eastern portion of the colony. These are the Berbice, the Canje and the Abary Rivers.

On the Abary, one has to ascend about twenty miles from the coast before Hoatzins are seen, and from here on they are scattered at irregular intervals for eight or ten miles, confined exclusively to the fringe of bushes on the windward side of the creek. So when we read that the Hoatzin inhabits British Guiana, instead of thinking of it as a bird of strong flight, which traverses savannas and forests, we must realize that it is to be found in only the merest fraction of the colony.

Taking again the large area drained by the rivers just north of the Orinoco delta, one finds Hoatzins absent except on the Rio Guarapiche, beginning two miles below the village of Caño Colorado.

I append a list of the localities from which Hoatzins have been recorded. Their isolated character, while doubtless reflecting our faulty and inadequate knowledge, hints also of the remarkably sporadic occurrence of these birds:

Colombia; Bogata, *Sclater* (40).
Ecuador; Rio Copataza, *C. Buckley.*
Peru; Cashiboya, *Scl. & Sal.* (42).
  Yquitos, *Berlepsch* (7).
Bolivia; Lower Beni River, *Allen* (1).
Venezuela; Caño del Toro, *Hornaday* (23).
  Orinoco from the delta to Rio Meta, *Cherrie* (16).
  Aqua Salada, *Cherrie* (16).
  Angostura, *Berlepsch* (7).
  Caicara, *Berlepsch and Hartert* (9).
  Guarapiche River, *Beebe* (5).
  Rio Guanare, *Bingham* (10).
British Guiana; Estuary of Berbice, *Brown* (12).
  Berbice, *Sclater* (41), *Quelch* (38).
  Abary Creek, *Quelch* (37), *Beebe* (6).
Dutch Guiana; Maroni River, *Perrin* (35).
  Indefinite, *Penard* (34).
French Guiana; Approuague, *Berlepsch* (8).
Brazil; The Hoatzin seems to be abundant locally "in the marshy regions which border the Amazon and its tributaries," *Goeldi* (20).
  Para, Amazon, Rio Negro, Rio Solimoens, *Astlett* (2).

Amazona inferior, Est. do Amazonias, Rio Juruá, *von Ihering* (25).
Santarem, *Pelzen* (33).
Lower Rio Capim, *Goeldi* (21).
Obidos, *Sclater.*
Marajo Island, Rio Anabiju, *Brigham.*

The lower Amazon may thus be considered as a center of distribution from which the birds have slowly extended northward into the Guianas and the Orinoco region; north-west to Colombia; west to Ecuador and Peru; south-west to Bolivia and south to the various tributaries of this greatest of rivers. Not one of these localities is separated by a real water-shed, and all are in communication with the Amazon, either by direct tributaries, or by marshy *itabos,* or river-joiners.

PART V—GENERAL APPEARANCE.

As far as general appearance goes, the name "Pheasant" is not far amiss when applied to the Hoatzin. It comes closest in general aspect to the chachalacas, but there is something strongly suggestive of a peacock, especially in the carriage of the neck and head. This is well shown in the positions of some of the individuals in Fig. 11.

My descriptions are based on 15 adult Hoatzins from the following localities: Ciudad Bolivar (9); Guarapiche (1); Bogata (1); Bolivia (1); Peru (1); Amazon (1); Abary, British Guiana (1).

FIG. 10. Beak of Hoatzin.

There is apparently no distinguishing sexual character, and remarkably little variation in size. However, the bird which I collected in the Guarapiche, although adult, is distinct from all the others in color, and if these characters should be found to be constant in other individuals, the birds in this isolated locality would form a distinct sub-species.

The beak of the Hoatzin is peculiar in shape, and a better idea can be obtained from the outline drawing, than from the description alone. The mandibles are deep and wide, the average measurements of fifteen specimens being as follows: culmen 29mm., depth of mandibles at gape 22mm., width at gape 19mm. The striking character of the mandible is the shortness of the gonys—this being only about 9mm., or one-fifth of the total length of the mandibles. The mandibles are slaty-olive, lighter on the edges. The nostrils are round, and placed about midway between the eye and the point of the beak. The sides of the head are almost bare, being covered only with a very scanty growth of black, bristle-like feathers on cheeks, ears and lores. Two rows of these function as eye-lashes. The bare skin about the eyes is nile blue in color, shading into cobalt on the other unfeathered parts of the head. The irides are carmine.

The bristles on the upper lores point upward, their tips interlocking on the forehead. Just back of them begins the long waving crest which is such a marked character of this species. The crown feathers are reddish-buff; in those on the occiput the buff darkens and becomes a shaft stripe, while the edges and tips of the feathers are black. The longest measure about four inches. The feathers of the upper parts as a whole are dark brown, with a distinct olive-green iridescence. The feathers of the nape and neck have pale, buffy shaft-stripes, this color changing to white on the mantle. In some specimens the scapulars are margined with white. The outer edges of the thumb feathers are pale buff, corresponding in shade to the feathers of the chin, throat and breast. Most of the wing coverts are tipped more or less broadly with white, forming three distinct wing bars.

The under wing coverts and primaries are of a rich maroon or chestnut, this hue being duplicated in the feathers of the sides, belly, flanks, and most of the under tail-coverts. The tips of the primaries are olive-green like the back, and the under and upper tail-coverts are black. The tail consists of ten feathers all of which are tipped with a broad band of buffy white.

The Hoatzin harmonizes well with its environment, the dark upper color and the splashes and streaks of white and buff breaking up its body-form into sunlight and shadow. When sitting quietly, either perching or on its nest, it is extremely difficult to detect, and its fear of hawks, shows that this concealment may perhaps serve a useful purpose.

The most interesting thing about its coloration is the way the colors of the under parts are carried out in the wings. The

Fig. 12. Haunt of the Hoatzin, Abary River, British Guiana.

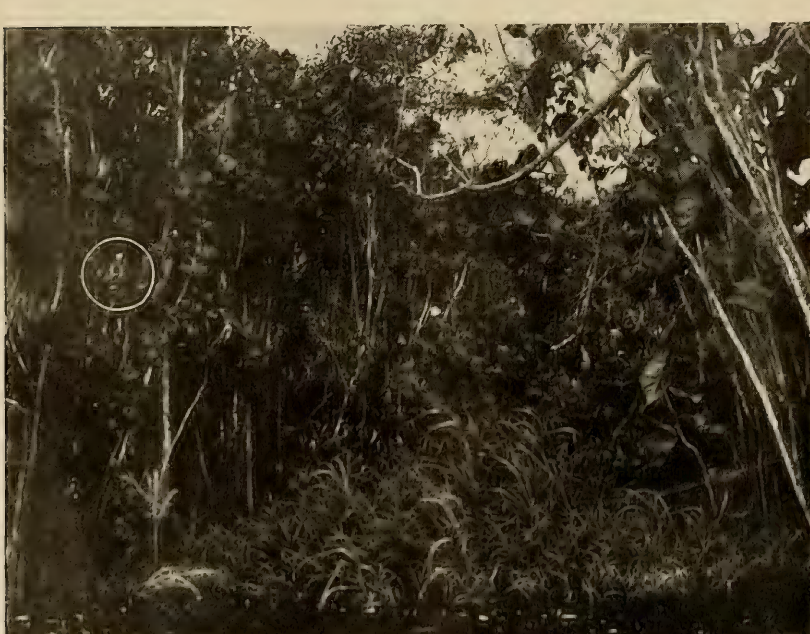

Fig. 13. Nest of Hoatzin in Dense Growth of Mucka-mucka.

pale buffy cream of the breast has spread, as it were, over the broad wrist edge of the wing, and the rich chestnut of the belly has infiltrated through the larger flight feathers. It is most difficult to account for this correlation of limb and body patterns,—a condition found in many reptiles and insects,—but it seems to emphasize the fact that some important environmental factor or cause must be concerned with this apparently directive evolution of just such colors being arranged in just such patterns, on totally different portions of the body.

When the Hoatzin is once alarmed, silhouetted against the sky, with wings and tail spread, and crest waving, no more conspicuous object can be imagined.

The total length of the Hoatzin is about 23 inches; the wing 12½; the tail 12; tarsus 2; middle toe and claw 3.

The single specimen already mentioned which I collected on the Guarapiche, differs from all the other Hoatzins I have examined in having no buff on the crest, this color being replaced by dark reddish chestnut; the buffy cream of the breast is darker, while the edges and shaft lines of the wing-coverts, mantle and scapulars are buff instead of white, and the lower parts instead of maroon are reddish buff. The bird is altogether unlike those from other parts of South America. It is fully adult.

Summing up the Hoatzin as a whole, we have a bird small of body with small head, short, curved beak, long, waving crest, and long, slender neck. The body plumage is loose and disintegrated, the wings and tail large in comparison with the body, and of strong, well-knit feathers,—all the more remarkable when we consider the weak flight, soon to be discussed.

The shortness and stoutness of the beak may safely be correlated with the toughness of its vegetable food. Its short feet rather belie their strength, as the bird seems to have little real power in them, and is forever balancing itself with wings and tail.

Part VI—Parasites.

The unpleasant odor which characterizes Hoatzins seems to have no effect on their insect parasites, and the cheek bristles are often encrusted with masses of the eggs of several large species of Mallophaga.

No thorough work has been done on the external parasites of this bird, but I obtained three species of Mallophaga from the Hoatzin shot on the Guarapiche River in north-eastern Venezuela. Two of these insects are new species and I have published their descriptions in Zoologica, Vol. 1, No. 4. I am in-

debted for their descriptions, and the following most interesting notes, to Dr. Vernon L. Kellogg of Stanford University.

Concerning the Opisthocomus Mallophaga, Dr. Kellogg says:

"The three species are:—

1. *Goniocotes curtus* Nitzsch—heretofore taken from *Opisthocomus* and no other host.

2. *Lipeurus*, sp. nov.—in the group *clypeata sutura distincta,* which group has been found heretofore only on maritime birds!

3. *Colpocephalum* sp. nov.—an extraordinarily spiny beast, not much like anything else in the genus.

"I am disappointed in finding these two new species. I hoped to find known parasites that might, by their relationship with other parasites, characteristic of the pheasants or the rails or some other group of birds, be a clue to the indication of your curious bird's plyletic affinities.

"The one known species of parasite, the *Goniocotes,* belongs to a group of Mallophaga best represented, and most characteristically, on the pheasants. But the *Lipeurus,* although a new species, belongs just as unmistakably with a group of Mallophaga characteristic of such birds as boobies, albatrosses, cormorants, frigate-birds, pelicans and such strictly maritime forms."

Part VII—Field Notes in Venezuela.

The first view which Mrs. Beebe and I had of living Hoatzins was two miles up the Rio Guarapiche, in south-eastern Venezuela, where we found a flock of eight on March 27th, 1908. Farther up we discovered three smaller flocks and later in the day a large assemblage of twenty-five individuals. The natives know them by the name of *Guacharacas de Aqua* and are well acquainted with the musky odor which emanates from their bodies. Being considered totally unfit for food, they are never killed and as a result have become extremely unsuspicious.

The following notes were written in the field:

The moment our dug-out comes into view the Hoatzins announce their presence by hoarse, croaking cries; grating and rasping to the ear like an unoiled wheel. Then, as we approach, those nearest flop or crawl inward through the branches, making a tremendous racket. This utterance has been termed a "hissing screech" by some writers and although a very poor description of the sound, no better one comes to mind unless it is a croaking hiss. Buffon (13) tells us "Its voice is very strong, and it is less a cry than a howl." Quelch (38) says "The cry of the Hoatzin

Fig. 14. Author Photographing Hoatzins.

Fig. 15. Female Hoatzin Flushed from Her Nest; Male Bird Approaching.

is usually heard when they are disturbed, and it is one of which it is not easy to give an exact idea. It recalls slightly the shrill screech of the guinea-bird, (*Numida*), but it is made up of disjointed utterances, like the notes heigh or sheigh (ei as in sleigh), pronounced with a peculiarly sharp and shrill intonation, so as to be quite hiss-like." The reckless way of thrashing through the undergrowth, and the apparent looseness of wing and tail and general carelessness of plumage bring to mind the crazy antics of anis, a fact not wholly uninteresting when we recall certain hints of cuculine structure in the Hoatzin.

Except during the extreme heat of mid-day, the Hoatzins prefer conspicuous positions overhanging the water on mangroves or other trees, among the foliage of which they roost at night. They appear to be extremely sedentary, and day after day we could be sure of finding the birds in the same place. We located nine flocks, ranging from a single pair to forty-two birds in number, and these seemed never to move from their favorite trees except when driven back a few yards into the jungle by our intruding canoe.

In these same trees over the water we found remains of many nests, in various stages of disintegration. As the number of the nests bore a fairly accurate relation to the pairs of birds, and as we saw these large, rough platforms of sticks at no other points, circumstantial evidence would indicate that the sedentary life of these Hoatzins is seasonal, if not, indeed, annual. We were told that they nest in May and June in this locality.

After they flop and clamber a few yards away from the canoe, they all quiet down and with waving crests, crane their necks at us in curiosity from their perches. Each time they utter their grating note, they raise the tail and wings, spreading both widely.

We had no opportunity of observing the quadrupedal habits of the young Hoatzins, but an interesting observation, first noted by Mrs. Beebe, was that this finger or hand-like use of the wing is present in the adults as well. They never fly if they can help it, and even when they pass over firm ground seem never to descend to it. But their method of arboreal locomotion is to push and flop from branch to branch. When the foliage and hanging vines are very thick, they use their wings, either together or alternately, to push aside the obstruction and to keep themselves from falling, until a firm grip has been obtained with the toes. This habit is extremely wearing on the primary feathers which become much frayed from friction against stems and branches.

I secured two specimens for the skin and the skeleton respectively and found them in an interestingly irregular moult. In one (Coll. No. 1138), the right 3rd primary, and the left 4th, 7th and 10th, are about half grown. In the tail, the next to the outer pair and the right central rectrices are in the same stage of growth, while blood feathers are scattered here and there over the body.

The second Hoatzin examined (Coll. No. 1139), was in a still more dishevelled condition of plumage. Both wings and tail were badly frayed and broken. Instead of the full number of ten tail feathers, only five were present, one of which was half grown. Three blood-filled sheaths just appearing above the surface of the skin, represented the remainder. In the right wing, the 2nd, 8th, 18th, 19th and 20th were considerably less than half grown. The head, back and thighs of this individual showed heavy moult, besides many growing feathers over the rest of the body.

The crops of these birds were distended with a finely comminuted mass of bright green vegetable matter, the leaves of the mangroves and some other river growths.

In one crop, scales and the remains of a small fish were also present, and as we once saw a Hoatzin with dripping plumage, creeping from the water up a slanting mangrove root, it may be that the adult birds retain some of the natatory skill which characterizes the nestlings. This, however, is mere conjecture. The scales in this instance were those of the little four-eyed fish (*Anableps anableps*), so common about the muddy shores of the Caños.

Part VIII—Field Notes in British Guiana.

On April 12th, 1909, Mrs. Beebe and I reached a bungalow used as the headquarters of a rice plantation, some twenty miles up the Abary River in British Guiana. Through the kindness of Mr. and Mrs. Lindley Vinton we obtained permission to remain here several days, with excellent opportunities of studying the Hoatzins. Three days after our arrival, Mrs. Beebe had the misfortune to break her arm and we were compelled to leave at once, with only a few notes and photographs. These are, however, of sufficient interest to warrant publication.

The Abary River is, at this point, some twenty yards across, and winds through a great treeless savanna marsh in a general north and south direction. The east bank is for the most part clear of growth except for the reeds and grasses of the savanna. Along the western bank is a dense shrubby or bushy line of vege-

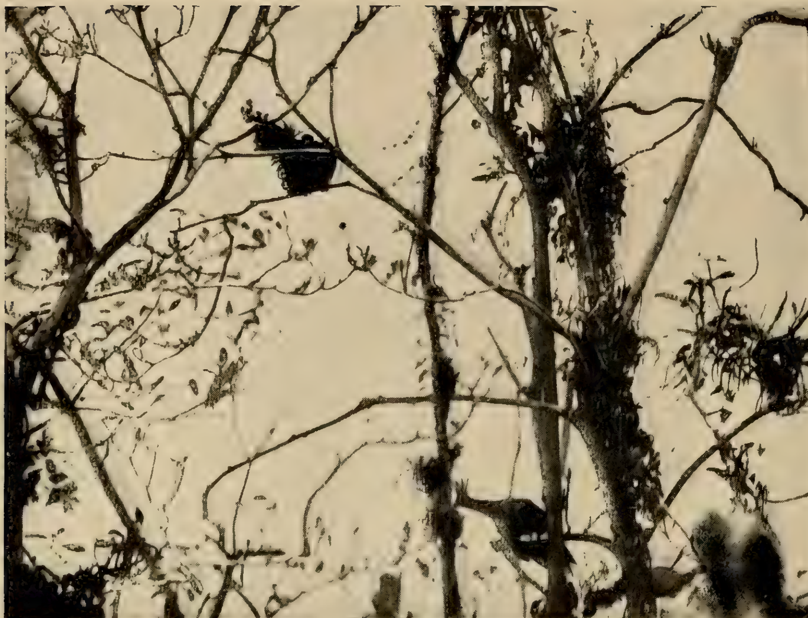

Fig. 16. Female Hoatzin in the Same Position; Male Having Flown Nearer.

Fig. 17. Male Hoatzin Alarmed and About to Take Flight.

tation; at times rising to a height of twenty or thirty feet or again appearing only two or three yards above the grass and reeds beyond.

The presence of this bushy vegetation on only one side of the river is probably due to the prevailing winds, which blow from the east. The bush grows altogether in the water and consists chiefly of a species of tall arum, or mucka-mucka as the natives call it, frequently bound together by a tangle of delicate vines. Here and there is a tree-like growth, white-barked with entire obtuse leaves. This narrow ribbon of aquatic growth is the home of the Hoatzins, and from one year's end to another they may be found along the same reaches of the river. In general, their habits do not differ from those of the birds which we observed in Venezuela.

Throughout the heat of mid-day no sight or sound reveals the presence of the birds, but as the afternoon wears on, a single raucous squawk may be heard in the distance, and we know that the Hoatzins are astir. Directly in front of the bungalow, between it and the river, the brush has been cut away on either hand for a distance of about sixty yards. Every evening, from 4.30 to 5.30 P. M., the Hoatzins gather on the extreme northern end of this wide break in their line of thickets, until sometimes twenty-five or thirty birds are in sight at once. Some fly down to the low branches and begin to tear off pieces of the young tender shoots of the mucka-mucka. With much noise and flapping of wings, several soon make their way to a single bare branch which projects over the cleared marsh.

The first bird makes many false starts, crouching and then losing heart, but the next on the branch getting impatient, nudges him a bit, and at last he launches out into the air. With rather slow wing beats, but working apparently with all his power, he spans the wide expanse of clear bush, then the ten feet of water, then fifteen yards more of stumps, and with a final effort he clutches a branch—and his goal is reached. After several minutes of breathlessness, he makes his way out of sight into the depths of the brush. A second Hoatzin essays the feat, but fails ignominiously and falls mid-way, coming down all of a heap among the stumps. Here a rest is taken, and for five or ten minutes the bird may feed quietly. Then a second flight carries it back to the starting point or on to the end of the open space.

Sometimes when the birds alight and clutch a twig, they are so exhausted that they topple over and hang upside down for a moment.

Watching the Hoatzins carefully with our stereo glasses for several evenings in succession, we came to know and distinguish individual birds. Two, one of which has a broken feather in the right wing, and the other a two-inch short central tail feather, are excellent flyers, and, taking their flapping start from the high branch, never fail to make their goal, going the whole distance, and alighting easily. All of the others have to rest and one which is moulting a feather in each wing can achieve only about ten yards. This one fell one evening into the water at the second relay flight, and half flopped, half swam ashore.

One evening a Hoatzin flew toward us and alighted near some hens on the ground, but took wing almost instantly back to his brush-wood. A day or two before we came, one of the birds had used a beam of the porch as a perch.

This general shifting occurs at both sunrise and sunset, and is apparently always as thorough and noisy as we found it the first evening of our stay. For months, we were told, it had been kept up as regularly as clock-work.

In the morning as the sun grows hotter, the birds become more quiet and finally disappear, not to be seen or heard again until afternoon. They spend the heat of the day sitting on their nests, or perched on branches in the cooler, deeper recesses of their linear jungle.

The last view of them in the morning as the heat becomes intense, or late in the evening, usually reveals them resting on the branches in pairs close together. On moonlight nights, however, they are active and noisy, and come into the open to feed.

The habit of crouching or squatting down on the perch is very common with the Hoatzins, and it may be due to the weakness of the feet and toes. I am inclined, however, to consider it in connection with the general awkwardness in alighting and climbing, as a hint of the inadaptability of the large feet to the small size of the twigs and branches among which it lives. Inexplicable though it may appear, the Hoatzin—although evidently unchanged in many respects through long epochs—is far from being perfectly adapted to its present environment. It has a severe struggle for existence, and the least increase of any foe or the appearance of any new handicap would result in its speedy extinction.

Part IX—Food.

The Hoatzin is unquestionably a vegetarian and the remains of the previously mentioned four-eyed fish in the crop of one of

my Venezuelan specimens must have been evidence of an abnormal diet.

Examinations of the stomachs of individuals from various localities show that two or three species of marshy plants furnish almost the entire menu of this bird. One is the mucka-mucka or arum (*Montrichardia arborescens*), a tall plant of spindley growth, with large, tough, heart-shaped leaves, and a pineapple-like fruit. The leaves, flowers and fruit are all eaten.

Hoatzins also feed on the *Drepanocarpus lunatus*, and, both in Guiana and Venezuela, devour the tough leaves of the White Mangrove (*Arvicennia nitida*). Bates (3) includes the Sour Guava (*Psidium*) and "various wild fruits," in his list of its food.

Part X—Nest and Eggs.

At the time of our arrival on the Abary the Hoatzins had just begun to nest. They were utilizing old nests which, although so apparently flimsy in construction, yet are remarkably cohesive. The nests are almost indistinguishable from those of the "Chows" or Guiana Green Herons (*Butorides striata*), which were built in the same situations. The latter were usually placed low over the water, while the Hoatzins' were higher, from five to twelve feet above the surface of the marsh. The twigs were longer and more tightly laced in the Hoatzins' nests, and while the Herons' nests crumbled when lifted from the crotch, the others remained intact. The Hoatzins placed their nests in a crotch of the white-barked trees, or more rarely supported by several branched mucka-mucka stems. Both sexes assist in the building, as we observed two birds collecting and weaving the twigs. Three sets of eggs which came under our observation numbered, respectively, two, three and four. From what information I could gather, two seems to be the usual number. There is no foundation for the assertion that these birds are polygamous.

There is little accurate data in regard to the date of nesting of Hoatzins. It is possible that it differs in different places, and that no definite limits can be set to cover the species as a whole.

On the Orinoco, near Ciudad Bolivar, Cherrie (16) records that the nesting season extends from early in June until mid-September, thus including the height of the rainy season. Quelch (38) in British Guiana found the Hoatzin nesting from December to July, and thinks it "very likely that it is continuous throughout the year."

In Venezuela, the last of March, the birds were not nesting, and those examined showed no signs of a recent breeding season. In mid-April in British Guiana the Hoatzins were just beginning to nest.

The eggs are rather variable in shape. One which I have from the Orinoco is elliptical, while my Abary specimens are oval. The ground color is creamy white. The entire surface is marked with small, irregularly shaped dots and spots of reddish brown, inclining to be more abundant at the large end. The brown pigment deposited early in the oviduct is covered by a thin layer of lime and thereby given a lavender hue. The size averages 1.8 by 1.3 inches.

Part XI—Enemies.

Hoatzins seem to be very free from enemies, although from year to year their numbers remain about the same. The waters beneath them are inhabited by otters, crocodiles, anacondas and voracious fish, so that death lies that way. They seem also to fear some predatory bird, for whenever a harmless hawk skims over the branches on the lookout for lizards, the Hoatzins always tumble pell-mell into the shelter of the thick foliage below.

Part XII—Photographing Hoatzins.

We found that the best time to approach and photograph the birds was during their siesta. As we paddle along the bank, they scramble from their perches or nests up to the bare branches overhead, calling hoarsely to one another. Pushing aside the dense growth of Arums and vines, we work our canoe as far as possible into the heart of the brush to the foot of some good-sized marsh tree perhaps a foot in diameter. I step from the boat to the lowest limb, Mrs. Beebe hands me the big Graflex with the unwieldy but necessary 27-inch lens, and I begin my painful ascent. At first all is easy going, but as I ascend I break off numerous dead twigs, and from the broken stub of each issues a horde of black stinging ants. These hasten my ascent and at last I make my way out on the swaying upper branches. (Fig. 14.) From here I have a fairly clear view of the surrounding brush and if I work rapidly I can secure three or four pictures before the Hoatzins take flight and hide amid the foliage.

Of all my pictures, that of Fig. 11 is the prize. We came upon a flock of Hoatzins late in the afternoon and were fortunate

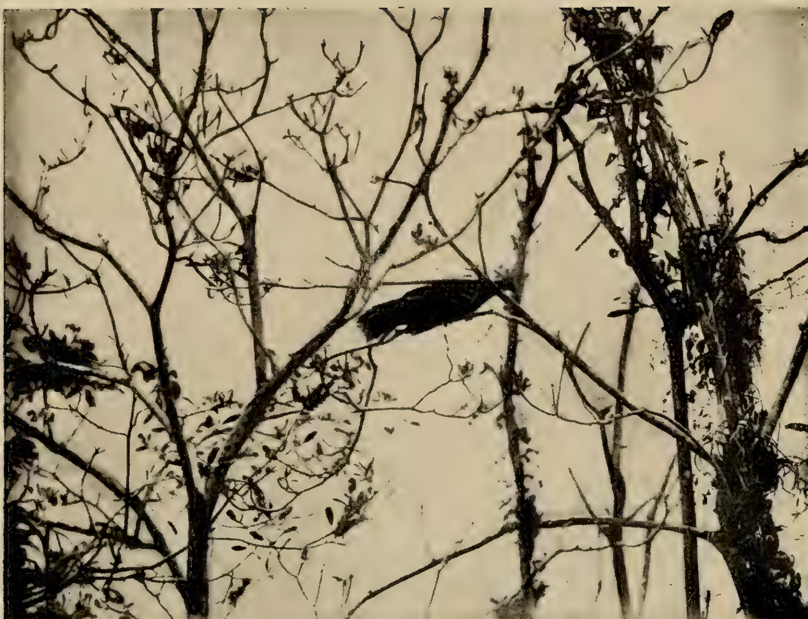

Fig. 18. Female Hoatzin Crouching to Avoid Observation.

Fig. 19. Female Hoatzin Taking Flight with Wings Fully Spread; a Second Pair of Birds Leaving Their Nest in the Background.

enough to get into a clear space and to photograph *eleven* on the same plate; the confused mass near the center of the picture containing four individuals. Fig. 12 shows the character of the country where we found the Hoatzin on Abary Creek, with the line of dense growth on one side, and the level savanna on the other.

A photographic study of an individual pair of birds is given in Figures 15 to 19. The action of these two birds is so typical of Hoatzins that an account of them will apply to the species in general. I made these photographs from a boat, standing on the thwarts, while Mrs. Beebe guided it through the brush.

We flush the female from her nest, and she flies to a branch some eight feet higher, the male then appearing from a tree beyond. (Fig. 15.) We remain perfectly quiet, and the next photograph shows the female Hoatzin, tail on, looking about, while the male, who has flown nearer, is watching us suspiciously. (Fig. 16.)

Fig. 17 shows the male on another perch, still more alarmed, and a moment later he thrashes his way out of sight. Meanwhile the female has rediscovered us and crouches down (Fig. 18), hoping to avoid observation, but as we push closer to the nest, she rises on her perch, spreads wings and tail to the widest (Fig. 19), her scarlet eyes flashing, and, uttering a last despairing hiss, launches out for a few yards. At this moment, as may be seen in the same picture, a second pair of birds fly up from a nest in the next clump of undergrowth, and raise their discordant notes in protest at our intrusion.

The assertion which I made last year that Hoatzins use their primary feathers as fingers, in the same way that the chicks and partly grown young use their wing claws, has been received with some doubt, and I am glad to offer a photograph (Fig. 19) as evidence. In the right wing of the Hoatzin, the thumb feathers are plainly visible, with their edges fretted away, while the first six primaries also show signs of severe wear, such as would be expected from the rough usage to which they are put.

Attention is called to the apparent immobility of the crest, which is as fully erect in the crouching Hoatzin (Fig. 18) as in the same bird a minute or two later, alert and about to fly (Fig. 19).

Thus it was that we made the first photographs ever taken of these most interesting birds.

Part XIII—Odor.

In regard to the odor given off by the flesh of Hoatzins and its cause, there seem to be many conflicting statements. I quote some opinions:

"I never found the smell of these birds so bad as I had been led to believe; it reminds one of a rather strong cow-shed. It has been found on cutting out the crop, as soon as the bird is dead, very little unpleasant odor remains." Loat (27).

"As is well known, the aroid shrub upon which the Canje Pheasant feeds gives its flesh a strong and disagreeable odor." Sclater (41).

"The popular name (*Catingueira*) is derived from a certain penetrating odor. This disagreeable odor is transmitted and adheres with such efficacy that it is an excellent protection, not only against the attacks of carnivorous animals, but also against persecution by man." Goeldi (20).

"Even by man they are seldom meddled with, except for scientific purposes, since a peculiar and unpleasant odor attaches to the flesh, especially after death, and which seems to be due to the penetration of the fluid and gaseous contents of the digestive tract. On this account they are not generally eaten, but a few cases have been reported to me in which they have been utilized for food." Quelch (38).

"The flesh has an unpleasant odor of musk combined with wet hides—a smell called by the Brazilians *catinga;* it is therefore uneatable." Bates (3).

On our Venezuelan trip we heard a great deal, and were warned again and again concerning the frightful odor which was supposed to characterize these birds. Some said they would have to be skinned under water! We found this wholly false. When skinning or dissecting one of these Hoatzins, one notices the faintest of musky odors, not at all unpleasant, and indeed perceptible only when the attention is directed to it. Our specimens were certainly most inoffensive in this respect, and the flesh of one which we cooked and ate, while it was tough, was as clean and appetizing as that of a Curassow.

In British Guiana the above experience was repeated, although the "Stinking Pheasant" was held in horror by the blacks. But, as before, we could detect nothing but a slightly musky odor. The odor is exceedingly persistent and is given off by skins which are several years old. Its cause is problematical and the direct connection with the crop is very doubtful. There is little doubt but that Hoatzins differ greatly, either seasonably or individual-

ly, in regard to the intensity of this odor. Far be it from me, however, to emphasize any lack of it, for the very thread of existence of this most interesting bird hangs upon belief in this inedibility.

The Indians and other inhabitants of South America who depend upon wild game for food never waste powder, shot or arrows on so-called sport. Until the "civilized" tourist penetrates to these regions, the Hoatzins are safe. When he does arrive protection must be given to these interesting birds—a heritage to us from past ages. So helpless are they, that, given a week's time and a shot-gun, one man could completely exterminate them in the colony of British Guiana. Fortunately the game laws of that colony are comprehensive and wisely made, and the Hoatzins are probably safe for many years to come.

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Fig. 21. Flock of Scarlet Ibises Among the Mangroves.

AN ORNITHOLOGICAL RECONNAISSANCE OF NORTHEASTERN VENEZUELA

PART I—ITINERARY.
PART II—GENERAL CHARACTER OF THE PURE MANGROVE FOREST.
PART III—GENERAL CHARACTER OF THE MAINLAND FOREST AND THE PITCH LAKE.
PART IV—ANNOTATED LIST OF BIRDS OBSERVED.
PART V—ECOLOGICAL CONCLUSIONS CONCERNING THE BIRDS OF THE ORINOCAN REGION.

PART I.—ITINERARY.

Leaving New York on February 22nd, 1908, via the Royal Mail Steamer "Trent," Mrs. Beebe and the writer arrived at Trinidad on March 9th.

Never were strangers more hospitably received than were we in the prosperous little capital of the island of Trinidad.* After lengthy negotiations, we secured a sloop of twenty-one

*The success of our trip was insured by the kind interest of many persons both in Trinidad and Venezuela, among whom I may mention Mr. Anduse, Mr. Guiseppi, Señor Toro, Señor Don Escobar, Mr. Alfred Lynch, Mr. B. E. Stoute, and especially Mr. Eugene André and Mr. Ellis Grell.

FIG. 20. Map of Our Route in Venezuela.

tons, flying the Venezuelan flag, and under the trusty guidance of Captain Truxillo and the less certain aid of a crew of four men, we left port on the evening of March 24th.

After an exceedingly rough passage of a night and a day across the Gulf of Paria, we glided with the tide up the broad Caño San Juan. We passed the inspection of the Commandante of the Ponton guardship, and proceeded as far as our sloop would float at high tide up the Rio Guarapiche. In the row-boat and in curiaras or dug-outs we then reached our port of entry, Caño Colorado, consisting of a custom house or rather hut, together with a few Indian houses. Having secured our permit to cruise along the coast, we spent our time exploring the mangroves which composed the principal part of this whole region.

At last we disembarked at Guanoco, a small native village, the shipping port for the pitch from La Brea, the great lake of this substance. Here we were hospitably entertained by the Venezuelan receiver by order of the Trinidad gentleman, Mr. Grell, who was financing the works at this time, and here we spent the remainder of our stay in exploring the surrounding country.

At midnight of April 14th, we left Venezuela and returned to Trinidad on the large tug used by the Pitch Lake Company.

The account of the expedition falls naturally into two major divisions, the Mangrove Swamp, and the High Land at La Brea with the surrounding jungle.

The list of birds is compiled from notes made during twenty days' observation in this region, and represents at least the more abundant species found in this circumscribed area of mangrove swamp and jungle edge.

The classification adopted is, in the main, that of Sharpe's "Handlist."

Part II.—The Pure Mangrove Forest.

General Character, Flora and Fauna.

The real coast of the portion of Venezuela which we traversed is shut off from the open gulf by a vast region of deep, blue-black mud, covered with an impenetrable jungle of mangroves and *no other terrestrial plants.* For mile upon mile one paddles through a region of pure culture mangroves—a forest of a single tree. These mangroves are in all stages of bud, flower and fruit, and are most interesting, both as land-makers and land-conservers. Deep channels intersect this area, cutting it up into islands of smaller or larger size, the larger channels being

known as caños, and are really the river deltas of this region, such as the Guarapiche and the San Juan. At high tide one may penetrate deep into the mangrove swamps in canoes, or curiaras as the native dug-outs are called, but low tide empties these of water, leaving exposed the soft ooze. One cannot step upon this, and in all this lower region there is hardly a foot of hard ground. This outermost zone we may designate as that of Pure Mangroves.

Going westward through the Caño San Juan we come to the Rio Guarapiche. This river, from its mouth up to above the village of Caño Colorado, is an excellent epitome of the gradually changing conditions in this region.

At the mouth and for a mile up stream the mangrove reigns supreme. Then orchids and other epiphytes appear, together with a scattering of weak vines and lianas, and now and then the fronded head of a small palm. For a long distance the mangrove holds its own along the banks, its roots bathed by the ebb and flow of the tides. We may call this the Mixed Mangrove region. Finally we observe that the jungle in the background has become wholly terrestrial in character, tall palms and great forest trees draped with a dense mass of lianas and epiphytes, and from the forest fringe the mangrove finally disappears altogether.

At Caño Colorado we find a typical mainland but rather marshy flora, which may be known as the region of Pure Forest.

From the very gulf edge, throughout all this outer zone, monkeys are fairly numerous. We found a species of large black spider monkey (*Ateles*); at least two species of capuchins (*Cebus*); squirrel monkeys (*Chrysothrix*); and the big red howlers (*Mycetes*). The latter seldom range far into the zone of pure mangrove forest, and became more numerous as we approached the dry land jungle.

Spiny rats (*Loucheres*), are found on the mangrove roots, miles from dry land and at least one species of opossum (*Didelphys* or *Chironectes*), also reaches the gulf edge. A small species of squirrel (*Sciurus*), with brilliant rufous under parts extends far into the inner zone of pure mangrove forest, although it is hard to imagine of what its food can consist.

Far from the waters of the gulf we find schools of dolphins (*Delphinus*), playing and feeding in the caños, but in spite of most thorough search we saw no signs, and could learn nothing from the natives, of the occurrence in this region of the manatee.

The characteristic birds of the outer mangrove zone are chiefly aquatic. Gulls, terns, plovers, sandpipers, herons, mus-

covy ducks, scarlet ibises, snake-birds, martins, tree swallows, cream-headed hawks and vultures. The mangrove blossoms attract numbers of insects, and we found such birds as *Todirostrum maculatum* and *Dacnis bicolor* near the gulf edge, many miles from dry land.

Small and medium sized crocodiles, pale gray in color, were not uncommon in the brackish zone and were the only reptiles observed. Tree-toads were heard here, but no Amphibians were observed or collected.

Fish were abundant, and if they had been the object of our search we could have secured many species.

At the turn of each tide thousands of medium-sized catfish (*Pseudauchenipterus nodosus*), would come alongside the boat and remain motionless for about an hour, all, like the sloop, facing the current. They would bite at anything from a piece of red cloth to a bit of raw yam.

With meat for bait we could catch large catfish, twelve to twenty-four inches in length, yellowish, with a very long spine on the dorsal and pectoral fins. This is known as the crucifix fish, from the striking resemblance of the interior of the dorsal cephalic armor to a human figure on a cross. It is a delicious food fish. The most abundant and interesting fish of the mangrove swamps is the four-eye (*Anableps anableps*).

The mangrove fiddler crab was by far the most abundant form of invertebrate life, swarming over the roots and lower portion of the stems. A small mollusk (*Neritina*), came next in point of numbers. A few biting flies annoyed us now and then during the day, and at night *Anopheles* in swarms hummed outside our netting.

Part III.—General Character of the Mainland Forest and the Pitch Lake.

As soon as the mangroves give place to a more mixed growth, and at La Brea, far beyond the influence of the tides, the character of the flora and fauna changes radically.

Among the mammals we find sloths, agoutis, ocelots, jaguars and pumas appearing. The agoutis and pumas had half-grown young at the time of our visit, in early April. Tree porcupines and kinkajous were observed, besides peccaries, pacas and deer, and several species of opossums. The four latter animals penetrate far into the swampy and marshy brackish areas, while the others keep altogether to solid ground.

FIG. 22. Nest and Eggs of Great Blue Tinamou.

FIG. 23. Red-tailed Chacalaca.

The varied bird, reptilian and insect life of the South American continent becomes bewildering as soon as the mangroves are left behind. Among the birds, cassiques, hummingbirds, toucans and tanagers predominate; large tegus crawl along the water's edge, and myriads of lesser lizards swarm in the underbrush. The fish in the pools at La Brea are interesting from their varied forms; among others we observed the common *Hoplias malabaricus*, several species of *Aequidens* and *Callicthys*.

At this season Hymenoptera, especially ants and wasps, were more abundant than other insects, but heliconias, dragon flies, cicadas and large brush-legged Hemiptera were also common. Large banded Mollusks (*Ampullaria glauca* and *A. cormearietis*) breed in the forest pools, and mosquitoes were almost absent. Tarantulas, scorpions and centipedes, while abundant, were never troublesome. A single specimen of *Peripatus* was found associated with scorpions in rotten wood.

Part IV.—List of Birds Observed in Northeastern Venezuela

From March 25th to April 14th, 1908.

Order TINAMIFORMES.

Tinamus tao Temm. Great Blue Tinamou.

The conventional remark concerning this tinamou which one finds repeated in many volumes—in English, Spanish, Portuguese, German and Dutch,—as originally given in the British Museum Catalogue, Vol. XXVII, page 499, is as follows: "This large species is easily distinguished by the dark olive-slaty tinge of its plumage." In fact, little more seems to be known concerning the bird.

It is apparently of wide distribution, recent authorities differing on the limits of its range as follows:

Venezuela, Colombia, Amazonia, Peru (Sharpe's "Handlist," Vol. I, p. 8).

Matto Grosso, Borba, Para, Amazonia, Bolivia, Peru, Colombia, Guyana, Venezuela (von Ihering's "As Aves do Brazil," p. 4).

The first news we had of this bird was at the village of Guanoco, where some of the natives and Indians recognized a painting I showed them, calling it "*gallina del monte con los huavos azules*," which at once identified it.

We found that the tinamou inhabited dense jungle, especially on the slopes of rather steep hill-sides, and in such places

their high pitched, rolling trill would occasionally be heard. To catch sight of them was a difficult matter, and only twice did they give us an opportunity to use our glasses and gun. The dark cross bars or markings show distinctly on the dorsal plumage, which, in shadow, appears strongly bluish.

On April 12th, after hearing a bird call near at hand, we forced our way toward it into an open glade, a former clearing of some Indian, or made by the cutting of trees for the Pitch Lake Company.

A tinamou was seen to creep stealthily along close to the ground, keeping near a rotten log. As it crouched and sprang into the air in flight, we secured it, and found it was of this species. It proved to be a male bird, with the breast feathers much worn from incubating. Near where we first caught sight of the bird we found a nest with two eggs still warm from the heat of the parent's body. (Fig. 22.) It consisted merely of a slight hollow scratched in the ground near the end of the log, in a rather open patch of grass. One egg was clear, the other was about to hatch. They are of a medium shade of shining turquoise blue, the egg containing the embryo being about a shade darker than the other. The inner surface of the shell is pale, pearl-gray. In shape they are spheroidal, with almost equally rounded ends. The measurements are: the clear egg 56 x 48 mm., the fertile egg 58 x 48 mm. I can find but two references to the egg of *Tinamus tao.*

Thein. Fortpflanz. ges. Vog., p. 22. T. V. f. I. 1845.

H. von Ihering. Revista do Museu Paulista, IV, p. 297. 1900. (This is a reference to Nehrkorn; Katalog der Eiersammlung, Braunschweig, p. 247. 1899.)

Near the end of our stay we learned that a second nest containing a set of four eggs of this species had been found on April 3rd and the eggs placed under a hen. We could learn nothing of their subsequent fate.

(At least one other species of tinamou was heard calling, but could not be identified.)

Order GALLIFORMES.

Penelope argyrotis (Bonap.). Rufous-tailed Guan.

A pair of these birds was seen near the Caño Colorado about sunset on March 30th. They were perched high up in a dead tree, looking like large blackish turkeys, the sunlight shining with a rich scarlet glow through their throat wattles. One was secured.

Ortalis ruficauda Jard. RED-TAILED CHACHALACA.

We saw two specimens of this bird which were voluntarily associating with some fowls in an Indian's clearing at Guanoco. They had become accustomed to the sight of the people, and came daily from the neighboring forest to feed with the hens. Fig. 23.

As throughout the southwest of the United States, Mexico and Central America, so here it was firmly believed that chachalacas occasionally cross with common fowls, the offspring making fine game-cocks. Also as elsewhere no specimens of such hybrids could be produced.

Three other chachalacas were seen at a distance and the wild nocturnal chorus of these birds was occasionally heard. The natives call them "*pavos del monte,*" monte in this and other cases meaning, not mountain, but low forest.

ORDER COLUMBIFORMES.

Leptoptila verreauxi Bonap. RUSTY GROUND PIGEON.

This was the only member of the Columbiformes which came under our notice. On a mangrove branch overhanging the water of Caño Guanoco a pair had built their frail nest and were incubating two eggs. We discovered them on April 2nd.

ORDER OPISTHOCOMIFORMES.

Opisthocomus hoazin (Müll.). HOATZIN.

Common in small flocks on the Guarapiche River.

For the notes made on this species see ZOOLOGICA No. 2, pages 54 to 56.

ORDER RALLIFORMES.

Aramides axillaris Lawr. VENEZUELAN WOOD RAIL.

These handsome birds were occasionally seen on the mud islets in the mangrove swamp, especially at the mouth of the Rio Guarapiche. It was impossible to stalk them but if one sat quietly in the curiara, they would soon appear, walking swiftly and silently over the mud, jerking neck and tail in unison. The flesh was strong and fishy as the food consisted chiefly of small crabs. At night their sudden, unearthly cry would occasionally ring out close to the sloop, to be taken up and answered by birds farther and farther off until the notes died away in the distance. It was a high, long-drawn-out yelping, the rhythm of which was frequently broken by the notes of some neighboring bird.

Order PROCELLARIIFORMES.

Oceanites oceanicus (Kuhl.). Wilson Petrel.

A single individual was blown by the storm into the quiet waters of the Caño San Juan when we entered the mangroves on March 25th. It flew close to the sloop and alighted twice on the water.

Order LARIFORMES.

Phaëthusa magnirostris (Licht.). Great-billed Tern.

These terns, with their conspicuous bright yellow feet and bills, attracted our attention on March 25th at the entrance of the San Juan, where a dozen were flying slowly about or perching on the mangrove snags left exposed by the tides. Occasionally they rose upward and dived headlong after fish. We saw none higher up. The large ungainly-looking bill reminded one of the mandibles of their relation—the skimmer.

Rhynchops nigra cinerascens Spix. Black-tailed Skimmer.

A single bird, probably of this species, passed us March 25th, at the mouth of the San Juan, skimming as it flew.

Larus atricilla Linn. Laughing Gull.

A dead specimen of this bird was picked up on the water at the mouth of the San Juan. Two other gulls, apparently of the same species, were seen flying at a distance at the same place.

Order CHARADRIIFORMES.

Aegialitis semipalmatus (Bonap.). Semipalmated Plover.

Aegialitis collaris (Vieill.). South American Collared Plover.

Large flocks of plovers were wheeling about or running over the mud flats at the mouth of the San Juan where we anchored March 25th. They proved to be of these two species, *semipalmatus* being in much greater numbers. None were seen farther inland.

Numenius hudsonicus Lath. Hudsonian Curlew.

The body of one of these birds in an advanced condition of decay was found on the muddy shore of the Caño San Juan, March 26th. The humerus had been broken and partly healed.

Helodromas solitarius (Wilson). Solitary Sandpiper.

April 9th two of these birds were seen in a pool of water at the side of the narrow-gauge track leading from Guanoco to

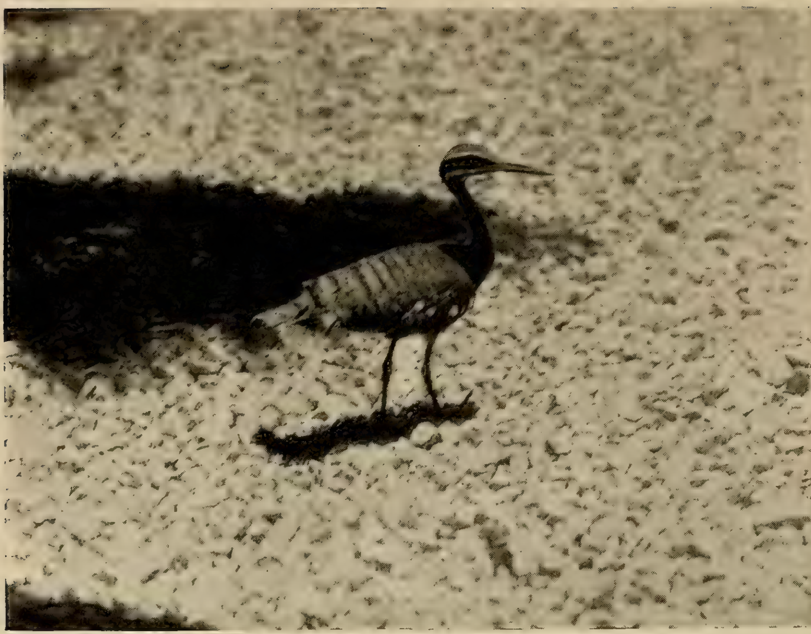


FIG. 24. Sun-bittern.

FIG. 25. White-headed Chimachima Hawk and Moriche Palm.

La Brea. The following day a male was secured on the lake itself. It had been feeding on insects and spiders near the edge of the pools scattered over the pitch.

Tringoides macularia (Linn.). SPOTTED SANDPIPER.

We saw a number of these little friends on March 25th, at the very outer limit of the mangroves, the mouth of the Caño San Juan. On April 2nd we found them abundant along the Caño Guanoco and on the 9th a single one was seen near the railroad track, half way to La Brea.

Gallinago paraguaiae (Vieill.). SOUTH AMERICAN SNIPE.

A single male of this species was secured on the pitch lake, April 10th.

Jacana jacana (Linn.). SPUR-WINGED JACANA.

Common about the pools at La Brea. On April 10th we saw at least thirty, flying slowly about, cackling shrilly from time to time. Their beautiful colors were very conspicuous as they held their wings straight upward over their backs for some time after alighting. A number in the immature plumage were among them. One secured was in full breeding condition.

Oedicnemus bistriatus (Wagl.). DOUBLE-STRIPED STONE PLOVER.

One bird, apparently not in fully adult plumage, was seen at La Brea, April 10th.

ORDER GRUIFORMES.

Aramus scolopaceus (Gmel.). SOUTHERN LIMPKIN.

Three or four of these strange birds were seen along the banks of the Caños, none however as far down as the territory where the mangroves held sole sway. Their nocturnal cry was not heard during the trip.

Eurypyga helias (Pall.). SUN-BITTERN.

Sun-bitterns are fairly numerous throughout the central mangrove region, where a more terrestrial flora begins to appear. One was also seen at La Brea on April 9th. They are tame, unsuspicious birds but extremely difficult to observe owing to their coloring. The indefinite patterns of their plumage seem to assimilate with any combination of light and shade.

The sun-bittern creeps quietly from the underbrush and steps slowly and daintily over the mud, stopping now and then

to lunge at a fly or other insect—its body swinging from side to side, in the characteristic manner of this bird. When the bird stands head on, its slim head and neck vanish from view, and if one's eyes are removed for an instant it is very difficult to rediscover the bird. Its flight is buoyant and heron-like.

The only sound we heard from these wild birds was a sweet but penetrating, high double-note, uttered frequently in early morning. Both notes are equal, each lasting about a second, and the final one is a half-tone higher, thus closely resembling the call-note of *Tapera.* The pitch is the second G and G# above middle C on the piano.

Sun-bitterns were great pets with the Indians, and we saw several which were perfectly tame, enjoying full liberty, one of which chose to perch most of the time on the shoulder of its mistress. We secured this bird before we left, and it is still living in perfect health in the New York Zoological Park.

Psophia crepitans Linn. COMMON TRUMPETER.

We heard the curious, muffled, rhythmic, rumblings—one certainly cannot call them trumpetings—of these birds several times before we caught sight of them. This was an excellent view of three individuals which slowly crossed the track ahead of us and, flying heavily across a ten-foot pool of water, stalked into the impenetrable underbrush beyond. One individual, before it disappeared, leaped upward and seized a berry or insect from a leaf overhead.

ORDER ARDEIFORMES.

Eudocimus ruber (Linn.). SCARLET IBIS.

These birds were seen only on the Caño San Juan, from the very mouth up to a distance of several miles inland. Not a bird was visible at high tide but with the uncovering of the mudflats, the scarlet ibises began to appear singly and in small flocks. They were, without doubt, the most abundant bird in all the mangrove region into which we penetrated. In every flock of thirty or forty, some six or eight would be birds in the brown plumage of immaturity.

On the evening of March 26th a flock of not less than five hundred birds swung back and forth across the caño ahead of us, in a series of graceful evolutions before rising and drifting out of sight over the dark green mangroves, like a great cloud of living flame. They were quite wary and when feeding did not allow one to approach within gun-shot before flying. The flocks

however, often passed within a few yards of the sloop. These mangrove jungles, impenetrable to man, form a vast natural game preserve in which these birds may roost and nest safe from all except their natural enemies.

I obtained a bird from an Indian who had broken its wing and had cared for it until it recovered. It was in full adult plumage, scarlet from tip of beak to tip of toe. Shortly after placing it in the flying cage in the New York Zoological Park it moulted all the feathers on the head and neck, and a scattering through the scapulars, coverts and back. The new plumage, with the exception of the lesser coverts, came in pale salmon instead of the original brilliant scarlet, and at the present date the contrast is striking. The salmon tint of the new plumage is exactly that of another individual which has been in captivity since February, 1905, and has now (December, 1909) passed through five annual moults. So in the case of my ibis, the loss of color was not gradual but sudden, and its cause was certainly not due to absence of sunlight, heat or moisture. I am not yet prepared to say, however, that change in food alone was the cause.

Ardea cocoi Linn. Cocoi Heron.

Several of these wary birds were observed three miles up the Caño San Juan.

Florida caerulea (Linn.). Little Blue Heron.

After the second mile up the Caño San Juan and throughout the whole length of the Caño Guanoco, these herons were abundant, adults predominating. Later, at La Brea, we saw small flocks of birds mostly in the immature white plumage.

Leucophoyx candidissima (Gmel.). Snowy Egret.

Snowy egrets were seen in numbers on March 25th at the mouth of the Caño San Juan, and at La Brea six or eight of these birds were associating with young blue herons. Many were also seen along the Caño Guanoco. They were second in numbers, being excelled only by scarlet ibises.

Nyctanassa violacea (Linn.). Yellow-crowned Night Heron.

A single bird of this species in fully adult plumage, was perched at the mangrove's edge waiting for the tide to go down, as our sloop passed in at the mouth of the Caño San Juan on March 25th, and a few others were seen farther up stream.

Agamia agami (Gmel.). AGAMI HERON.

Several were at the mouth of the Caño San Juan, fishing in the shallows at the edge of the mud flats. Not seen again.

Canchroma cochlearia Linn. BOAT-BILLED HERON.

Several of these curious looking birds flew up as our sloop passed them on the Caño San Juan.

Butorides virescens (Linn.). LITTLE GREEN HERON.

Very abundant along the Rio Guarapiche, flying up at every turn, and exceedingly tame. On April 10th we saw several of these familiar little herons, at La Brea, but not until we secured two and carefully identified them, could we be certain that they were the same "fly-up-the-creeks" which haunt our northern mill-ponds.

ORDER ANSERIFORMES.

Cairina moschata (Linn.). MUSCOVY DUCK.

Two pairs of this splendid duck were seen at the mouth of the Caño San Juan on March 25th and no day passed during our stay among the mangroves when we did not see several pairs. They would waddle slowly out from the darkness of the inner swamp, their black plumage the very hue of the blue-black mud, and the scarlet caruncles about the eyes glowing in the sunlight. When the birds were flushed, the white wing-speculums flashed out brilliantly. They seemed to sift the mud for organic material and we saw them running awkwardly after the small mangrove crabs. We saw none away from the salt or brackish caños. They seemed to fly about more and to feed more freely toward night-fall.

Dendrocygna viduata (Linn.). WHITE-FACED TREE-DUCK.

We saw these birds only twice, on the upper Rio Guanoco, beyond tide water. I procured a tame pair which were in a bamboo fenced yard near an Indian's hut, associating with cats, dogs and chickens. These were said to have been caught when young a few miles farther inland.

ORDER PELECANIFORMES.

Phalacrocorax vigua (Vieill.). SOUTH AMERICAN CORMORANT.

A flock of nine birds flew across our bow in the Caño San Juan about a mile from the gulf. On March 30th we flushed a single cormorant from the Rio Guarapiche near Caño Colorado.

Anhinga anhinga Linn. SNAKE-BIRD.

On April 2nd as our sloop was drifting slowly up the Caño Guanoco, a male snake-bird rose from the water and flew heavily to a protruding snag, from which it watched us as we passed.

Fregata aquila (Linn.). FRIGATE BIRD.

Pelecanus fuscus Linn. BROWN PELICAN.

Numbers of these two species were seen in the first few miles of mangroves, along the Caño San Juan.

ORDER CATHARTIDIFORMES.

Catharistes urubu urubu (Vieill.). (?) BLACK VULTURE.

This was by far the more abundant of the vultures in this region. A flock was always perched on the roof of the village slaughter shed at Guanoco. As no specimens were secured I cannot be perfectly certain of the sub-species.

Cathartes perniger (Sharpe). (?) VENEZUELAN TURKEY VULTURE.

Turkey Vultures were abundant, although less so than the above species. We observed them on the very edge of the mangroves at the mouth of the San Juan. My only note concerning these is "common soaring as in Virginia, but they seem smaller than those in the north." I collected no specimens but from this observation and with the aid of Mr. Cherrie's criticism I judged them to be *perniger*.

ORDER ACCIPITRIFORMES.

Ibycter ater (Vieill.). BLACK CARRION HAWK.

We saw these birds first on April 10th at La Brea where three were flying about over the expanse of weed-grown pitch, calling hoarsely with raven-like croaks to each other. The natives know them as the ko-kai birds from their cry. One of the three, the tamest, was in a dull brownish, immature plumage, and although full grown, I saw him called and fed by one of the parents.

They were striking birds, the adults wholly black except for a wide band of white across the base of the tail, the head mostly bare of feathers and of an orange color, giving the bird the gen-

eral appearance of a turkey buzzard while the size of a crow. They were feeding on armored fish (*Callicthys*) which now and then leaped out of the small pools of water and died on the pitch. In the stomach of the male I secured was a skeleton of one of these fish.

Although vulturine in appearance and habit, these carrion hawks have not lost the power of grasping and can carry food to a branch where they hold it down and pick it apart at leisure. These birds are extremely tame and one sat unconcerned while a puffing little engine pulling a load of pitch passed within twenty feet. I heard these birds calling from the depths of the mangroves while drifting up the Caño Guanoco.

Heterospizias meridionalis (Lath.). Red-winged Hawk.

One of these small hawks hunted systematically over a small area of forest and an Indian's clearing near the railroad track. We saw it first on April 7th.

Rupornis magnirostris (Gmel.). Large-billed Hawk.

A single individual was often seen at La Brea, very tame, coming within fifty feet and circling about uttering a harsh scream.

Busarellus nigricollis (Lath.). Cream-headed Hawk.

From time to time as we drifted through the caños we saw these birds perched on the mangroves. They were on the lookout for crabs, which they seemed expert in snatching from the mangrove roots. The lower surface of the hind toe is covered with long, sharp-pointed horny spicules which must be of great assistance in seizing either crustaceans or fish. On April 10th one of these birds was seen near La Brea.

They are beautiful hawks, almost as large as a red-tailed *Buteo*, with the head and neck creamy buff and the body bright rufous. From a long distance their pale heads and red plumage stand out sharply against the dark green of the mangroves.

Urubitinga urubitinga (Gmel.). South American Black Hawk.

One of these birds perched for several hours in the top of a tall dead tree near our house at Guanoco, and early next morning it was in the same place, soon shooting swiftly away toward the high land to the west.

Leucopternis albicollis (Lath.). WHITE-HEADED CHIMACHIMA HAWK.

On April 9th I first saw one of these splendid birds perched in a dead tree at La Brea and every day after that I saw it frequently. It was absurdly tame, allowing us to go under the tree on which it sat, and not troubling to sail slowly to a neighboring palm until one threw a stick at it. It appeared to be watching the ground closely but we could not discover its prey (Fig. 25).

The head, neck, underparts and tail were pure white, so it was altogether a very beautiful and conspicuous bird, and most interesting because of its utter lack of fear.

Elanoides forficatus (Linn.). SWALLOW-TAILED KITE.

These graceful birds were not uncommon, swooping and soaring above the caños. On April 1st three kites swooped past my canoe on the Rio Guarapiche, repeatedly dashing down to the surface and scooping up a beakful of water before they rose again. I secured a male, and found it had just feasted upon several small species of beetles. On April 11th a pair of these birds passed slowly over the lake of La Brea.

ORDER STRIGIFORMES.

Glaucidium brasilianum phalaenoides (Daud.). SOUTHERN PYGMY OWL.

When we stepped out of the door of our house at Guanoco on April 4th, the first morning of our stay, we found one of these little owls perched in a pomerosa tree before us, with a half-eaten female euphonia tanager in its talons. When excited and nervous the tail is raised high, wren-like, and is then jerked at intervals, up, down and sideways.

I secured this bird, which proved to be a male in full breeding condition. In the stomach was the head of the unfortunate tanager, together with two small beetles.

We found the pygmy owls very numerous and both diurnal and nocturnal in their habits. In the glaring heat of mid-day and late at night their voices were equally in evidence. Their call is a series of ten to sixty whistled *coos*, given about three to the second in a monotone of the second E above middle C, or thereabouts. Whip-poor-will-like, the bird sometimes becomes excited, and hurries its utterances until they almost run together.

Their voice is very ventriloquil and it is often difficult to locate the little gray or red author; for both phases of plumage are found, although the gray birds are far more numerous.

We flushed one red bird which flew by closely pursued, and actually pecked, by two kiskadees, a blue tanager and a hummingbird. When it alighted it "froze" in characteristic owl fashion and its pursuers disappeared.

Acting on this hint we utilized the whistled *coo-coo-coo-coo* to draw birds out of impenetrable thickets, and found it invaluable. Sometimes a dozen species of small birds would exhibit their hatred and fear of this diminutive raptor by appearing at once with angry cries.

(We saw no other species of owl, but several times we heard a screech owl and occasionally the deep hooting of a *Ciccaba* or *Bubo* would come from the depths of the high land jungle.)

Order PSITTACIFORMES.

Ara ararauna (Linn.). Blue-and-yellow Macaw.

On March 29th at La Ceiba on the Rio Guarapiche we saw a single pair of these birds, perched in the top of a dead stub. They watched us on our sloop for a half hour, swinging upside down and shrieking their curiosity, their brilliant under parts glowing in the sunlight. At last they flew away close together, westward, high above the mangroves.

Ara macao (Linn.). Red-and-blue Macaw.

This was first seen March 27th on the Rio Guarapiche below Caño Colorado, and one or two pairs of these birds were seen or heard almost every day on the Caño Guanoco and along the railroad tracks near La Brea.

Ara macavuana (Gmel.). Red-bellied Macaw.

While in the Rio Guarapiche, some Indians brought two young macaws to the sloop. They could not fly, and had apparently just been taken from the nest. The Indians would give no information concerning them, except that they had been obtained a short distance away, near the river. They were clad in dull brown-black feathers, and not until they reached New York did they acquire the adult plumage, proving to be of this species.

Conurus aeruginosus (Linn.). Brown-throated Parrakeet.

On April 2nd we saw large flocks of these parrakeets, and in the high land jungle, and at La Brea we heard their shrill, rau-

FIG. 26. Nesting Stub of Yellow-fronted Amazon Parrot on Pitch Lake.

FIG. 27. Amazon Parrot at the Entrance to Her Nest.

FIG. 28. Nearer View of Amazon Parrot.

cous cries or saw them almost every day, usually in small flocks of four to twelve.

(Short-tailed parrakeets were seen on several occasions, but were not secured or identified.)

Amazona ochrocephala (Gmel.). YELLOW-FRONTED AMAZON PARROT.

Two birds of this species had their nest in an old dead palm stub about one hundred yards out on the expanse of pitch at La Brea (Fig. 26). We discovered it by accident, the old bird climbing to the entrance and peering out at us as we pushed through the tangle of weeds near by.

We returned later and secured three photographs of the parrot at the entrance of the nest, before she flew screaming to join her mate at the edge of the neighboring jungle.

The dead palm stub was seven feet in height, with the entrance of the nest five feet from the ground. This entrance was almost a vertical rectangle, measuring two and seven-tenths by five and a half inches. The whole interior of the stub was hollow, and the nest itself was three and a half feet below the entrance, the lower part having been partly hollowed out, or at least smoothed off, by the parrots. The nest consisted of nothing but a soft bed of chips, and it was perfectly clean and sweet-smelling. At the level of the nest the hollow measured ten inches in diameter, and the nest chips were six inches above the pitch outside.

There were two eggs and one young bird just out of the shell (Fig. 30). This nestling was thickly covered with white down. When I cut through the base of the palm stub and let in the warm sunlight, the young bird instantly showed symptoms of distress, uttering a low, raucous cry, like the subdued mewing call of a catbird.

The eggs are dull white, in shape like diminutive hen's eggs, and measure 39 x 30 and 38 x 30 mm. respectively. The egg from which the young bird had hatched was broken into two unequal parts, through a circle slightly nearer the blunt end.

Amazona inornata (Salvad.). GRAY-HEADED AMAZON PARROT.

A pair of these birds were often seen near our house at Guanoco, fearlessly climbing about the pomerosa trees while we watched them, and one was secured on April 9th half way to La Brea at the side of the railroad track.

Pionus menstruus (Linn.). BLUE-HEADED PARROT.

These birds were fairly common in small flocks along the Rio Guarapiche. We did not see them elsewhere.

Pionites melanocephala (Linn.). BLACK-HEADED CAIQUE PARROT.

These conspicuous green, yellow, black and cream-colored parrots were abundant among the trees along the Caño Guanoco where they were feeding and flying about in loose, noisy flocks. An Indian brought one to the sloop in adult plumage. Small flocks roosted occasionally in a tall dead tree near our house. The call note is loud but not unmusical.

ORDER CORACIIFORMES.

Ceryle torquata (Linn.). GREAT RUFOUS KINGFISHER.

Not uncommon throughout this region. The first flew past our sloop as we were entering the mangroves on March 25th at the mouth of the Caño San Juan, and the last was perched on a stub at La Brea, sitting quietly through a heavy downpour of rain.

Ceryle americana (Gmel.). RED-BELLIED KINGFISHER.

Three were seen at Caño Guanoco, and a pair near the railroad track at La Brea. They were also fairly common on the upper Guarapiche near Caño Colorado.

Ceryle superciliosa (Linn.). PYGMY KINGFISHER.

This least of all kingfishers is no larger than many hummingbirds. One mile up the San Juan we saw the first, and they were almost always in sight after that, on the Guarapiche and Guanoco Caños. A male which I secured shows six or eight large white feathers on the center of the lower breast, distinctly marked off from the under tail-coverts which are white as usual. As these little birds flew they flashed out brilliantly in the sunlight,—chestnut and green alternately.

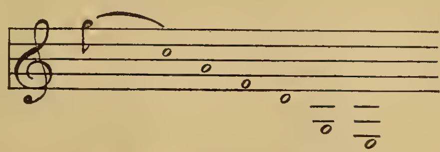
Nyctibius jamaicensis (Gmel.). POOR-ME-ONE.

We saw this bird only once in Venezuela but we often heard its unmistakable cry in the evenings in the high-land woods about two miles up the railroad track between Guanoco and La Brea. It was only after we returned to Trinidad that we had an opportunity of studying the bird at first hand, on Mr. Carr's cocoa estate at Caparo.

Fig. 29. Amazon Parrot About to Take Flight.

Fig. 30. Nest and Young of Yellow-fronted Amazon Parrot.

The notes I made at that place are of sufficient interest for insertion here. The call of this bird is of a most weird character,—a long, drawn out descending moan or diminuendo wail, ceasing abruptly and followed by three, four or sometimes five short notes uttered at regular intervals and successively lower and deeper in tone. The natives are not to be blamed for regarding this bird with deep superstition. Mr. Carr has written the call in musical notation thus:—



The birds began calling at about nine o'clock in the evening and would answer each other, and come nearer when one imitated the note. We drew one bird close to the house, and thereby nearly frightened an old creole man to death. It perched on exposed stubs and fence-posts, sitting stiffly erect with its tail pressed close to the stub, merging perfectly with the dead wood; seeming like a gray, mottled continuation of the stub itself.* When I flashed a strong electric light toward it, the eyes glowed like great orange globes of dull fire—the reddish-yellow choroidal vessels being brilliantly reflected. It was such a remarkable sight—these two great orbs glowing and

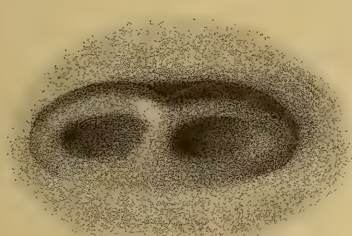


Fig. 31. Top View.

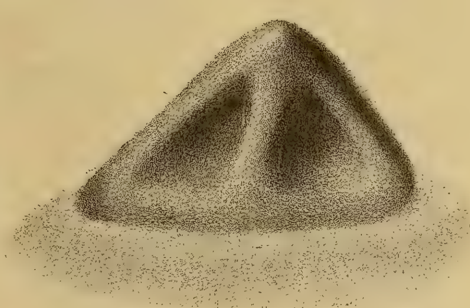


Fig. 32. Side View.

winking from out of the darkness,—that Mrs. Beebe and Mr. Carr who were with me were astonished. If one of the creoles had been present he would have fallen down and worshipped the

*For an illustration and description of this bird see Brewster and Chapman in The Auk, xii, pp. 208-211.

bird then and there! The bird ruffled its feathers and called twice before flying away.

I secured a male in full breeding condition, and found its stomach crammed with large horned scarab beetles. The pupil of this bird is enormous, in fact the iris is only just visible as a narrow, pale orange ring. The fundus oculi on close examination, show as pale pink, slightly clouded with gray. The pecten is of relatively medium size, and very simple. In shape it is a compressed cone with a flaring base; the rim and a bar down the center thickened and slightly lighter in color. The white disk of the optic nerve is wide, and visible all the way around the pecten, while the lamina cribrosa, represented by many minute dots, are confined to the inner portion of the disks. Little or no trace of radiating nerve fibers are visible, these being apparently entirely free from the neurilemma, and thus transparent. (Figs. 31 and 32.)

Nyctidromus albicollis (Gmel.). WHITE-NECKED PARAUQUE.

Not uncommon at Guanoco until April 9th, after which none were seen or heard. The call may be best represented by the syllables *wha-ahee-o!* This is usually uttered but once, and is then answered from a distance by another bird.

Claudia squamata (Cass.). FORK-TAILED PALM SWIFT.

A flock of these birds could always be seen hawking in the clearing about our house in Guanoco. A smaller number were seen at La Brea. They are very swallow-like in appearance and flight.

(Hummingbirds abundant and at least eight species were observed, but only four specimens were collected.)

Thalurania furcata fissilis Berl. and Hart. VENEZUELAN BLUE-COLLARED HUMMINGBIRD.

Common about the house at Guanoco. Several times this species flew into our room, and was unable to find its way out again. These birds would snatch small spiders from their webs in the corners of the walls. They were breeding at this season.

Eucephala caerulea (Vieill.). THE LESSER SAPPHIRE.

Heliothrix auritus (Gmel.). BLACK-EARED HUMMINGBIRD.

Both species were common among the flowering shrubs and trees along the railroad track near Guanoco. These birds and many other species haunted the heliconia water cups, in which

each morning there was always an abundance of drowned insects. The first species was in breeding condition.

Glaucis hirsuta (Gmel.). RUFOUS-BREASTED HUMMINGBIRD.

Common all along the upper Caño where they frequented a small white orchid which was blossoming in great abundance.

ORDER TROGONIFORMES.

Trogon viridis Linn. GREATER YELLOW-BELLIED TROGON.

These beautiful birds were common on the upper Guarapiche, often flying out near the water, then upward to some fruit or cluster of berries. Their soft cooing notes were a constant accompaniment to the other river sounds. A female which I secured had the stomach filled with small berries.

At Guanoco a pair of these trogons lived in the dense woods just behind our house. They were very tame, and one could approach within ten feet of them.

Trogon violaceus Gmel. LESSER YELLOW-BELLIED TROGON.

Less common than the larger species, but found in close association with them.

(The Indians recognized a picture of a red-bellied species of trogon and said it was found in this region, probably *Trogon collaris*, but we saw nothing of it.)

ORDER CUCULIFORMES.

Coccyges melanocoryphus Vieill. SOUTHERN BLACK-BILLED CUCKOO.

A pair of these birds was seen several times at La Brea. They were tame, and occasionally came close to one as they searched the lower thickets for insects. A third bird was secured and found to be in breeding condition.

Piaya cayana guianensis (Cab. and Heine). VENEZUELAN RUFOUS CUCKOO.

On April 3rd two of these birds appeared at the edge of the railroad track about one hundred yards from our house at Guanoco, calling to each other excitedly, and hinting in other ways that they had a nest not far away.

Piaya rutila (Illig.). LESSER RUFOUS CUCKOO.

Five of these little birds were gathered in a clump of brush at the edge of the pitch lake on April 9th.

Tapera naevia (Linn.). FOUR-WINGED CUCKOO.

This interesting cuckoo was observed only in the vicinity of the clearings made by the Indians, occasionally along the railroad track and twice at La Brea.

It attracted attention both on account of its notes and actions. The more common utterance is a penetrating double-toned whistle, recalling a note of the sun-bittern. When giving it the bird usually perches on the topmost twig of some dead tree. The tone is loud and clear, in a minor key, and the second note is slightly *higher* than the first (not *lower* as Chapman says, writing of this bird in Trinidad).*

The second call or song consists of six to ten similar notes, uttered in measured sequence, slowly ascending on a minor scale; then the bird slips down three or four tones and carries the scale higher than before, both phrases running smoothly into a single song.

If one attempts to imitate this latter song the bird pays no attention, but by hiding and giving even a single whistled note near the tone of the first described double utterance, the bird is thrown at once into great excitement. Perhaps in this case it is a male exhibiting anger at the suspected presence of a rival. It answers at once, sometimes adding a third higher half-tone to its call. With looping flight it swoops toward one and so accurately does it gauge the single note it has heard that it will often alight directly overhead or at least in the nearest dead tree. Here it shows its excitement by raising the crest feathers, flirting the tail and often the entire body from side to side, and —strangest of all—by repeatedly shooting the dark alulas or thumb feathers out across the pure white breast, the wings being kept motionless all the while and pressed close to the side. Until it discovers the fraud practiced upon it or until its excitement dies away, it utters the piercing double-note, perhaps once every three or five seconds. One may stand up and frighten the bird away with a shout, yet a whistle will bring it back at once. The movement of the alulas is observable at other times when the bird is calm, preening its feathers or hopping about the branches of a tree. I never saw one of these birds alight among foliage.

Crotophaga major Gmel. GREATER ANI.

These curious birds were common in small, straggling flocks all along the Rio Guarapiche and Caño Guanoco, sailing across

*Bull. Amer. Mus. Nat. His. VI, p. 64.

from one bank to the other or flopping helplessly among the branches. The natives have aptly named them *hervidores*—the boilers—from the bubbling quality of their notes, uttered when gathered together in a garrulous, sprawling crowd. In Guanoco, they were among the tamest birds about the house, and a flock was always attendant upon the grazing cows, feeding on the insects which flew up in the path of these animals.

Order SCANSORES.

Ramphastos haematorhynchus (Berl. and Hart.). (?) Venezuelan Red-billed Toucan.

The toucans we saw and collected were either of this species or *Ramphastos erythrohynchus.* I considered them as the former, but brought no skins back with me. Several were seen at Guanoco and a pair at La Brea perching in a dead tree near the lake. Their call was a loud, harsh *Kiok! Kiok!*

Ramphastos culminatus Gould. Lesser White-throated Toucan.

Four or five were seen along the Rio Guarapiche and two secured.

Pteroglossus aracari atricollis (Müll.). Black-necked Aracari.

On March 30th a pair of these birds alighted in a dead tree almost over the sloop, as we lay anchored at La Ceiba. On the 8th of April a second pair was seen at five o'clock in a tall tree at one side of our house at Guanoco. I secured the female which had the stomach filled with leaves, seeds and small insects.

Order PICIFORMES.

Galbula ruficauda Cuv. Venezuela Rufous-tailed Jacamar.

We first saw these birds along the Rio Guarapiche above the village of Caño Colorado. They were in pairs and seemed to remain within a radius of some fifty yards. On March 31st as we were paddling slowly upstream a sudden downpour of rain drove us to the shelter of a dense tree overhanging a perpendicular bank of bluish clay. While holding the dugout close to the bank a jacamar suddenly dived between us and disappeared into a hole in the bank within arm's reach. We watched quietly and soon its mate followed. A few minutes later a good-sized anaconda wound slowly out of a hole beneath the water

line. A second entrance apparently well worn by the passage of the serpent's body was higher up, above the water, and only three feet beneath the nest of the jacamar. Elsewhere the bank was pitted with the smaller holes of crabs.

These jacamars had three types of notes; the call-note was a series of sharp peeps like a young chick, while the alarm note was a single soft cluck. The song was a field sparrow's tempo set to the peeps of a newly hatched chick; slow at first and accellerating until the series ended in a rolling blurr of sound—all, however, in a monotone, never a trill.

They are indefatigable fly-catchers, sitting motionless on a branch until an insect passes when they launch out after it like a flash, much more kingfisher than flycatcher like. This pair of birds was feeding altogether on small dragon-flies and other Odonata, swallowing wings and all.

The nest in this instance was a slightly descending cylindrical tunnel 1¾ inches in diameter, showing no external hint of its occupancy. It differed from the numerous fiddler crab holes all about only in being slightly larger. The tunnel was ten inches long and ended in a chamber as big as one's fist. The nesting material consisted only of a thin layer of the harder parts of the small insects—elytra, legs and chitinized body segments, among which were a number of active fly larvae. There were four, glossy white eggs, almost round, and remarkably uniform in size. Three measure 22 x 18 mm. and the fourth 23 x 18 mm. The embryos were about three-quarters grown.

On April 9th we saw a pair of rufous-tailed jacamars perched in a bush near La Brea, singing.

Bucco bicinctus (Gould). DOUBLE-BANDED PUFF-BIRD.

A pair of these birds were perched close together high up in a tree near La Brea on April 9th. As they sat all hunched up they resembled diminutive laughing kingfishers. No note was heard but now and then one sallied forth after an insect and returned to its perch. The male which I secured had a number of small beetles in its stomach.

A peculiar characteristic of this bird is the bifurcated tip of the upper mandible, between the points of which the upturned point of the lower mandible is inserted. Thus the front view of the bird shows three sharp, curved points. This specimen shows three complete bands of black across the breast instead of two each posterior one successively narrower.

Fig. 33. Yellow Woodpecker.

Fig. 34. Northern Palm Tanager.

Melanerpes terricolor (Berl.). EARTH-COLORED WOODPECKER.

These birds were not uncommon along the middle and upper Guarapiche, calling noisily from the trees on the banks. I secured a female at La Ceiba on March 29th. A male of this species with a large part of the crown and nape scarlet, spent much of his time outside of our window at Guanoco, feeding on the pith of guavas. The bird would cling to one of the fruits and excavate it until he ate through his support, when both the fruit and the bird would fall, the latter freeing himself, and with a graceful curve swooping upward to a branch. Here he would clean his bill and feet and soon commence on another fruit. If frightened the bird would remain away but a few minutes, so fond was he of this delicacy.

Dendrobates kirki (Mahl.). RED-AND-GREEN WOODPECKER.

Several of these were observed and two secured. They were identical with individuals observed in Trinidad, where the bird is shot on sight owing to its devastation among the cocoa pods. The reiterated call is shrill and ventriloquil.

Celeus elegans (Müll.). YELLOW-CRESTED COCOA WOODPECKER.

On March 30th six of these birds flew into a tree over the sloop in the early morning. Later we found them common at Guanoco and along the railroad track. A female which I shot had been eating the seeds of a species of orchid.

In Trinidad a bounty is offered for these birds as they are very destructive on the cocoa plantations, boring into the unripe pods and drinking the milk.

Celeus jumana (Spix.). BROWN-CRESTED COCOA WOODPECKER.

Several were seen and one secured on the Caño Guanoco on April 2nd. Apparently much rarer than the former species, as no others were seen.

Crocomorphus semicinnamomeus (Reichenb.). YELLOW WOODPECKER.

We first saw these striking, bright yellow birds in the Caño Guanoco. When flying in the sun with the characteristic looping woodpecker flight, they were very conspicuous, shining brightly against the dark foliage. But when clinging to a trunk they merged perfectly with the patches of lichen and sunlight. At Guanoco they were not uncommon, drumming loudly on the trees near the house. They were not wary and I succeeded in getting an excellent photograph of one. These woodpeckers ex-

hibited considerable variation, some birds, doubtless immature, showing a much greater amount of brown on the plumage than others.

A female which I secured had several hundred very small ants in its stomach.

Campephilus melanoleucus (Gmel.). GREAT RED-CRESTED WOODPECKER.

Occasionally seen in pairs in the dense woods west of Guanoco. A male which I secured on April 13th had been feeding upon small iridescent green bees, which he had been chiseling out from a half-dead tree trunk.

Ceophloeus lineatus (Linn.). GREAT IVORY-BILLED WOODPECKER.

A pair of these splendid woodpeckers seemed perfectly at home among the Indian huts at Caño Colorado, calling from the nearest trees and flying to and fro overhead.

Another pair had a nest in a hole high up in the trunk of an unclimbable tree near our house at Guanoco. Their calling and drumming was one of the dominant sounds in early morning.

ORDER PASSERIFORMES.

FAMILY *FORMICARIIDAE.*

Thamnophilus doliatus doliatus (Linn.). CHECKED ANTBIRD.

This interesting ant-thrush was not uncommon along the railroad track, appearing usually in pairs and uttering a loud, drawn-out call. The sexes, as is often the case in this family of birds, are radically different in color, the male black, thickly barred and spotted with white, while the female is of a general rufous color. These ant-thrushes feed on insects which they find on the ground, often scratching for them among fallen leaves.

Thamnophilus canadensis trinitatis (Ridgw.). TRINIDAD BLACK-HEADED ANTBIRD.

The black-headed males and the rufous-capped females of this species of ant-thrush were fairly common in the undergrowth about the border of the lake of La Brea. They seldom left the shelter of the low bushes, except to descend to the ground now and then for an insect. All I secured were feeding on a small, green species of hemipter. A motion characteristic of these birds was to flirt the tail sharply and raise the crest, uttering at the same time a simple chirp.

Dysithamnus affinis andrei (Hellm.). ANDRE'S ANTBIRD.

This Trinidad form has not been taken in Venezuela before. A pair was seen at La Brea on April 10th and the male secured. Like other ant-birds they kept among the underbrush, feeding on small insects of various kinds.

(Several other species of ant-thrushes were seen but not identified. Among them were two rufous colored species, one with a black and white face and the other with black underparts.)

FAMILY *DENDROCOLAPTIDAE.*

Synallaxis cinnamomea (Gmel.). CINNAMON SPINE-TAIL.

At La Brea these birds were common in pairs wherever there were low bushes on the lake. Although they have the stiff, spiny, creeper-like tail of the typical woodhewers, yet they seem to have completely lost the climbing habit. They remind one constantly of marsh wrens in their jerky motions; flirting the tail and clinging to the upright stems of sedges, while in color they recall the female bearded tit.

The song is a series of squeaking or rattling chirps. The acquisition of such radically new habits without a corresponding change in structure is very interesting. A male which I secured had been feeding on small insects.

Dendrornis susurans susurans (Jard.). COCOA WOODHEWER.

Fairly common along the Caño Guanoco and the railroad track near La Brea. Days before we identified the bird we heard its sweet dropping song of eight or ten notes recalling some of the utterances of a canyon wren. Even when the song came from the tree directly overhead, it was almost impossible to locate the mottled brown singer while it clung motionless to the bark.

These birds were always to be found in the van of the armies of hunting ants, feeding both on the frightened winged insects aroused by their enemy, and on the ants themselves. The woodhewers fly to the ground, snatch their prey, and swing up to a tree trunk, where they brace themselves creeper-like, and if the insect is too large to swallow entire, they wedge it into a crevice of bark and eat it piecemeal. At other times they find their food in true creeper fashion, under pieces of bark and lichens and among the roots of aerial orchids and other plants. They were in breeding condition.

Dendrornis obsoleta notata (Eyt.). LESSER STRIPED WOODHEWER.

We found this bird common along the upper Rio Guarapiche, creeping as often along the under as along the upper side of horizontal branches. Those secured were feeding solely on arboreal ants of several species.

(At least four other climbing species of Dendrocolaptidae were observed but not identified.)

FAMILY *COTINGIDAE.*

Tityra erythrogenys (Selby). VENEZUELA RED-EARED TITYRA.

A pair of these birds were perched in a dead tree at La Brea on April 11th, the female with rich rufous ear-coverts. They uttered no note and we did not see the species again.

FAMILY *PIPRIDAE.*

Pipra erythrocephala (Linn.). GOLDEN-HEADED MANAKIN.

These exquisite little birds were not uncommon in the high woods north of Guanoco, where they were to be found in pairs. They were in full breeding condition and were feeding on insects alone. Although so conspicuous when in flight or in the hand, yet when perching among the lights and shadows of the forest, they became practically invisible, either the black body merging with the shadow, or the orange-yellow head with the sunshine; in either event the visible colored part bore no resemblance in shape to a bird.

Manacus manacus manacus (Linn.). WHITE-BREASTED MANAKIN.

These little birds were found under the same conditions as the golden-headed manakins, six or eight being sometimes seen during a morning's walk through the jungle. Their presence was made kown at a great distance by the loud whirring sound produced by the wings, each time the birds flew. Even if they only flitted to a branch a foot or two away, the four, narrow, outer primaries gave forth a sharp whirr. They were pugnacious and occasionally two males would fight fiercely. Their approach toward each other was by short flights, the birds puffing out the elongated feathers of the throat and holding their bodies in a peculiar upright position as they flew. Their food as far

as I observed them feeding and from the contents of the stomachs of several, consisted wholly of small insects. They were nesting at this season.

FAMILY *TYRANNIDAE.*

Fluvicola pica (Bodd.). WHITE-SHOULDERED GROUND FLYCATCHER.

The habits of these dainty little black and white terrestrial flycatchers came as a surprise to our northern ideas of the members of the family Tyrannidae. They were wholly terrestrial and of the twenty or thirty observed, we never saw one perch in a shrub or bush. They were very common on the lake at La Brea, *running* swiftly over the black pitch against which their white-cap, shoulders and underparts stood out in sharp contrast. They were tame and confiding and if we sat still for a few moments, the birds would come fearlessly within eight or ten feet. Their occupation was the pursuit of small insects, which they secured by swift running spurts or short flights, uttering a sharp, chirping cry as they flew. While scurrying swiftly over pitch and fallen logs these flycatchers wagged their tails continually, like water-thrushes, and from time to time uttered low, soft chirps. The simile was heightened by their preference for water, and true to their generic name they seldom carried on their insect hunting more than a few yards away from some pool. They were nesting or about to nest.

Arundinicola leucocephala (Linn.). WHITE-HEADED MARSH FLYCATCHER.

Closely associated with the above species was the white-headed flycatcher. The colors of the male were also black and white, but the pattern was more simple, the white being confined to the head, neck and a patch on each flank. In the males the upper mandible and the distal third of the lower, are black, the remaining portion of the under mandible being light yellow. They were in breeding condition.

There was no competition between these two pied, marsh-loving flycatchers, as they hunted in different strata. The white-headed birds kept altogether to the topmost twigs of low shrubs, from whence they now and then made quick sallies after passing insects in typical flycatcher fashion. A single sharp chirp was the only note I heard them utter. The females, distinguished by their gray upper parts, were more timid and hunted among the denser thickets.

Rhynchocyclus flaviventris flaviventris (Max.). YELLOW-GREEN BROAD-BILL FLYCATCHER.

Several of these flycatchers were seen at La Brea and one secured. Their mandibles snapped audibly when they closed upon some small insect prey but their general appearance and motions were of warblers rather than flycatchers.

Todirostrum cinereum cinereum (Linn.). GRAY TODY-FLYCATCHER.

Fairly common in the clearings about Guanoco and along the railroad track. One bird perched in a low tree was very tame and not alarmed at the closest inspection. It uttered a single, sharp call-note, and now and then dashed out after a passing insect which it seized with a loud snap of the bill. Within a period of ten minutes it repeated four times a simple, piping warbler-like song, sounding like *whit-o! whit-o! whit-o!* These birds were breeding at this season.

Todirostrum maculatum (Desm.). SPOTTED TODY-FLYCATCHER.

We saw several small flocks of this species on March 26th along the banks of the Caño San Juan about nine miles from its mouth. They were in family parties of three to five individuals, and were catching insects among the mangroves. Their call-note was a loud, sharp chirp, out of all proportion to so small a bird. They showed no fear of us and came within a few feet of the canoe.

This is the first time that *Todirostrum maculatum* has been recorded from the Orinoco region; British Guiana having been thought to be the northern limit of its range.

Colopteryx galeatus (Bodd.). HELMETED PYGMY FLYCATCHER.

On April 8th in the high woods back of Guanoco we first observed this tiny flycatcher. A male bird was perched about thirty feet up in a great tree, uttering a sharp, penetrating chirp at intervals, the sound being audible a long distance away. These birds seem to find a portion of their food in the calyces of flowers and the crevices of the bark as well as by pursuit on the wing. The Indians call them *copeton*. They were in breeding condition. Besides its extremely long, transverse crest, this pygmy flycatcher is characterized by the degenerate condition of the first three primaries of the wing, which are only two-thirds of the normal length of the other feathers. In its stomach were a number of small insects and one round seed.

Elaenia martinica flavogastra (Thun.). SOUTHERN YELLOW-BELLIED ELANIA.

On April 11th a pair of these flycatchers were preparing to nest in a tree at the edge of the pitch lake. They seldom left the vicinity of their nest site, except to descend to the low shrubby growth, from the topmost twigs of which they watched for passing insects, or occasionally to fly to the ground to snatch up some prey. Their call-note was a single hoarse cry. Their food consisted chiefly of small termites.

Myiozetetes cayanensis cayanensis (Linn.). CAYENNE FLYCATCHER.

These birds were fairly common, nesting at intervals along the Rio Guarapiche above Caño Colorado. The nests were built out over the water. A typical one found on March 31st, was placed on the stem of a prickly palm, leaning outward from the bank. It was a rough bundle of moss and plant down, covered over, with the entrance in one side, and contained half-fledged young. One could touch the nest only with the greatest difficulty, owing to the thorns on the stem and fronds of the palm, and it was perfectly protected from any terrestrial enemy.

Pitangus sulphuratus trinitatis Hellm. TRINIDAD KISKADEE FLYCATCHER.

These birds were nesting and exceedingly tame in the clearing about the Indian houses at Caño Colorado and also at Guanoco and for a mile along the track toward La Brea. Their loud-voiced, harsh cries awoke us every morning during our stay at Guanoco.

Myiodynastes maculatus maculatus (Müll.). STREAKED FLYCATCHER.

Streaked flycatchers were not uncommon about Guanoco and at the edge of the forest along the railroad track toward La Brea. Their call-note was a hoarse, croaking cry, and when alarmed they gave utterance to loud screaming notes. When approached quietly they showed little fear, often keeping their perch until one was within eight or ten feet. Ants, grasshoppers and small fleshy fruits composed the food of those which I examined.

There is such a remarkable external difference between two mated birds which I secured that it seems worth while to put it on record. Examination of a series of skins shows, however, that this variation is probably individual and not sexual.

I secured this pair of birds, male and female, of whose sex I am certain. They were mated and preparing to nest and were in full breeding condition, but are quite unlike in color and measurements. These differences tabulated, are as follows:

	♂ No. 1144.	♀ No. 1145.
Color of rectrices	chiefly black.	chiefly rufous.
Width of black marking on outer right rectrice, 10 mm. above tip of feather	8.5 mm.	4 mm.
Yellowish tinge on under parts	much stronger.	faint.
Color of crown patch	rich golden yellow.	pale lemon yellow.
Length of wing	112 mm.	109 mm.
Length of culmen	25 mm.	23 mm.
Width of bill at nostrils	11.5 mm.	13 mm.

It will thus be noticed that the male bird, in the color of its rectrices, partakes strongly of the character of *Myiodynastes solitarius*. The bills in this pair of birds differ as much as if they were two distinct species, the male's being long and narrow, that of the female short and broad.

Megarynchus pitangua pitangua (Linn.). GREAT-BILLED KISKADEE TYRANT.

Several seen near Caño Colorado. One secured had been feeding upon berries.

Tyrannus melancholicus satrapa (Cab.). LESSER WHITE-THROATED KINGBIRD.

A pair of these flycatchers were seen at the lake of La Brea on April 10th and later several others were observed along the line of the railroad and in the clearing about the huts of the Indians. A loud, strident cry was the only utterance heard. Small flies and beetles formed the principal port of the food.

These kingbirds were just beginning to build when we left. One nest site was in a tree in front of our house at Guanoco, both birds bringing material and arranging it in the crotch of the branch.

FAMILY *HIRUNDINIDAE.*

Progne chalybea chalybea (Gmel.). GRAY-BREASTED MARTIN.

A pair of these birds alighted on the mast of our sloop at the mouth of the Rio Guarapiche.

Tachycineta albiventer (Bodd.). White-rumped Tree Swallow.

These beautiful birds were common everywhere flying over the water, from the mouth of the Caño San Juan to the pools scattered over the pitch at La Brea. They were tame and occasionally alighted on the sloop's mast or bowsprit.

(Two other species of martins or swallows were seen but not identified.)

Family *TROGLODYTIDAE*.

Troglodytes musculus clarus Berl. and Hart. Venezuelan House Wren.

A pair of these wrens had a nest at our very door-step at Guanoco in the hole of a tree some twenty feet from the ground, and on April 4th both parents were carrying small spiders to their young. The song is less buoyant and elaborate than that of our northern house wren.

On April 12th a wren was seen and heard in full song at the Guanoco pitch wharf.

Family *MIMIDAE*.

Donacobius atricapillus (Linn.). Black-capped Mocking-thrush.

A pair of these handsome, active birds was nesting or preparing to nest in a clump of dense undergrowth at the edge of the pitch lake. Their song was very loud and was uttered from the topmost twig of some low bush. It was a simple reiteration of the syllables *chew! chew! chew! chew!* for thirty or forty times, uttered rapidly but at regular intervals.

Several birds were seen in thickets along the railroad track near Guanoco and a female which I secured on April 11th had been feeding on small hymenoptera, and was in breeding condition. In no bird of this species which came under our observation was there any trace of the white superciliary streak characterizing *Donacobius albovittatus*.

Several times I was struck by the general superficial resemblance between this bird and the cuckoo, *Coccyzus melanocoryphus*. When seen at a distance, the general color scheme and the white-tipped rectrices made a second look necessary to differentiate the two.

Family *TURDIDAE.*

Planesticus gymnopthalmus (Cab.). Bare-eyed Robin.

We observed several of these birds at Guanoco and heard their song. This closely resembles the song of our northern robin with now and then a liquid phrase like that of the wood thrush and an occasional sharp, metallic note.

Planesticus phaeopygus (Cab.). White-throated Robin.

One pair and an immature bird were seen in a clearing near Guanoco. A sharp, robin-like alarm note was the only utterance heard. Small beetles formed the chief food of this species.

Family *VIREONIDAE.*

Vireosylva chivi agilis (Licht.). Northern Active Vireo.

These birds preferred the higher branches of the dense forest near Guanoco. In such places their song, a brief sweet warble, would often be heard. Those secured were feeding on small hymenoptera.

Pachysylvia aurantiifrons saturata Hellm. Venezuelan Pachysylvia.

Not uncommon in the underbrush near clearings. The song was a sweet vireo-like warble. In appearance and actions these birds are very warbler-like. They catch small insects on the wing and also search for them in the crevices of bark. They were fearless, and in their excitement when pursuing insects would come within a few feet.

Family *MNIOTILTIDAE.*

Seiurus noveboracensis noveboracensis (Gmel.). Northern Water-thrush.

Every day which we spent at the pitch lake, we saw several of these familiar birds walking and tipping along the edges of the pools.

Geothlypis aequinoctialis (Gmel.). Venezuelan Yellow-throat.

These handsome warblers, so much larger than our northern yellow-throats, would occasionally appear for a moment at the edge of the marshy thickets along the railroad track near La Brea. In action they resembled their northern relatives, but the song was less jerky, softer and more drawn out.

Setophaga ruticilla (Linn.). AMERICAN REDSTART.

A male in full plumage was seen among the mangroves at the mouth of the Rio Guarapiche on March 28th, and two other males near Guanoco feeding on the small winged insects which flew up before an army of hunting ants.

Basileuterus auricapillus olivaceus Chapm. TRINIDAD WARBLER.

A pair of these birds was seen in the underbrush near Guanoco. The male, which was secured, was in breeding condition and had been feeding on small, green cut-worms. They seemed slow in their movements, searching the under side of leaves for insects, and uttered no sound.

FAMILY *FRINGILLIDAE.*

Sporophila minuta minuta (Linn.). PYGMY SEEDEATER.

A flock of fifty spent much of their time in the grassy clearing in front of our house at Guanoco, roosting at night in an isolated bush in a field. Small flocks would fly up before the pitch trains all the way to the lake. The males with their bright chestnut under parts were far out-numbered by the females. They were extremely tame and were feeding altogether on very small weed seeds. Their call-note was a sharp chirp, besides which individuals of both sexes would occasionally mount to the top of a bush and utter a musical, twittering song.

Sporophila gutturalis (Licht.). YELLOW-BELLIED SEEDEATER.

This species was found in company with the flocks of *Sporophila minuta minuta,* but in much fewer numbers. No song was heard, but the call-note was similar to that of the more abundant species.

FAMILY *COEREBIDAE.*

Cyanerpes cyaneus (Linn.). YELLOW-WINGED HONEY CREEPER.

Only two individuals of this species, both males, were seen. The one secured had been feeding on small insects, and was in breeding condition. The birds were in rather tall trees near the clearing at Guanoco.

Cyanerpes caeruleus caeruleus (Linn.). BLUE HONEY CREEPER.

On April 6th, a mile up the railroad from Guanoco, a female of this species dashed past us in a bit of marshy palm forest.

I secured it and found it had been feeding on the small seeds of an orchid. It was nesting or about to nest.

Dacnis cayana cayana (Linn.). TURQUOISE HONEY CREEPER.

We found a pair of these birds on April 8th at the edge of the high woods back of our house at Guanoco. They had been feeding on two kinds of seeds, one yellow and the others round and black.

Dacnis bicolor (Vieill.). TWO-COLORED HONEY CREEPER.

Two loose flocks of these birds were observed on March 26th, some in company with *Todirostrum maculatum.* They were fly-catching among the mangroves along the Caño San Juan, about nine miles from its mouth. A female had been feeding on small insects.

Coereba luteola (Cab.). VENEZUELAN BANANAQUIT.

On March 30th a flock of five of these birds spent a half hour searching for insects in the tree which overhung our sloop at La Ceiba on the Rio Guarapiche.

FAMILY *TANGARIDAE.*

Euphonia chlorotica (Linn.). PURPLE-THROATED EUPHONIA.

Several were observed along the Rio Guarapiche and one which flew on board was secured. It had been feeding on small berries.

Euphonia melanura Scl. BLACK-TAILED EUPHONIA.

A pair had a nest in a dense patch of undergrowth at the edge of the forest, back of our house at Guanoco. A female euphonia, half eaten by a pygmy owl, corresponded, as well as it was possible to tell, to this species.

Calospiza mexicana vieilloti (Scl.). VARIEGATED CALLISTE.

A flock of five of these beautiful birds was seen on April 7th near a clearing two miles up the railroad track from Guanoco. They were fly-catching and although as a rule they kept well to the tops of the trees, yet when pursuing some active moth or other insect they occasionally dashed down to within a few feet of our faces. Their call was a sharp twittering note. A male which I secured had been feeding altogether on small insects.

Tangara cana Swains. Blue-shouldered Tanager.

These birds were common at Guanoco, both about the house and at the edge of the forest along the track. A few were seen along the Guarapiche.

Tangara palmarum melanaptera Scl. Northern Palm Tanager.

On April 5th three were seen in a dead tree back of the house at Guanoco. These birds were tame and often came to the very door-step, searching for insects. At five o'clock in the afternoon of the same day a flock of about seventy-five went to roost for the night in a dense foliaged vine climbing up a tall dead tree in the center of the village. We found that this was their regular custom every night. They called to one another in sharp lisping tones, sounding like *swaa-swee!*

Ramphocelus jacapa magnirostris (Lafr.). Northern Silver-beaked Tanager.

These tanagers were nesting and carrying grubs to their young near our house at Guanoco early in April. One secured, had been feeding on small insects. Two pairs were also nesting near La Brea.

Tachyphonus luctuosus Lafr. et D'Orb. White-shouldered Tanager.

Common in small flocks all along the Rio Guarapiche, keeping well up in the tops of the trees. They continually flirted their wings, showing the white shoulders and under coverts. The call was sweet and modulated like the call-note of a canary. A male had its stomach filled with small termite workers.

Tachyphonus rufus (Bodd.). White-lined Tanager.

A pair of these birds was seen in the forest undergrowth near Guanoco on April 4th when they were nesting.

Phoenicothraupis rubra rubra (Vieill.). Cardinal Ant-tanager.

A pair of these birds were carrying grasses near La Brea on April 9th. A third bird was secured and had been feeding on small termites.

Schistochalmys atra (Gmel.). Black-faced Gray Tanager.

Three of these birds, all in adult plumage, were always to be found in a certain patch of dense scrub at the edge of the

pitch lake. A male secured on April 9th was in breeding condition and had been feeding on small seeds.

The same locality was inhabited by several male black-headed ant-thrushes, *Thamnophilus canadensis trinitatis,* and at a distance there was a striking resemblance between these two unrelated species, which were nesting in close proximity to each other.

Family *ICTERIDAE.*

Ostinops decumanus (Pall.). Great Black Cassique.

Fairly common and generally distributed through the deeper forest. Here and there along the Rio Guarapiche, their nests, fully three feet in length, could be seen, attached, in groups of three to eight, to the outermost twigs of giant, smooth-boled trees. These were wary birds and usually left their nests when we came within sight, and would not return for many minutes. Their notes were like deep, resonant cow-bells, ringing out clear and metallic and audible a long distance through the jungle.

The nearest nests of this species, a group of five, were about three hundred yards distant from our house at Guanoco. The black cassique seemed invariably to trust to the unclimbable character of its nesting tree to avoid its arboreal enemies. Their chief food consisted of small berries and insects, especially beetles.

Ostinops viridis (Müll.). Green Cassique.

A pair of green cassiques were completing a three-foot nest on April 12th. It was placed like those of *Ostinops decumanus,* high up in an enormous isolated white-boled tree fifty yards in front of our Guanoco house. On the same branch was the remains of last year's nest. Their call-note resembled those of the black cassique, consisting of a series of four or five deep, metallic clinks.

Cacicus persicus (Linn.). Yellow-backed Cassique.

One of the dominant avian features in the fauna of this region was this interesting bird.

We first noticed them at Caño Colorado, where, in a tall isolated tree, standing in the center of the village clearing and directly in the rear of the custom house, were over one hundred and fifty nests. These were in all stages of construction, a few in the process of being built while some birds were carrying food to their young, and other nests were already deserted. Many scores of birds were in sight at once in the tree, while those re-

FIG. 35. One Hundred and Fifty Nests of the Yellow-backed Cassique in One Tree.

FIG. 36. Nest and Eggs of Yellow-backed Cassique.

turning and leaving, made the air bright with their black and yellow plumage. This was the largest colony which came under our observation.

At Guanoco we found them nesting in several trees close to our house, there being thirty-five in one pomerosa tree. The height of the nesting was over in early April, although new nests were being built.

Smaller colonies of from four to fifteen nests were scattered at irregular intervals in the more open parts of the jungle—each of these being grouped closely about a large wasps' nest. At La Brea a medium sized, isolated tree, growing well out on the pitch, held forty nests.

We made careful inquiries concerning these birds and the consensus of reports from many persons lent truth to the facts. These *"arrendajos,"* as the natives call them, nest principally in February and March, then disappear entirely, not a bird being seen for months. In August and September they return and nest a second time, after which they again migrate or at least disappear from this vicinity.

These cassiques showed real intelligence in the selection of a site for their nests. Monkeys, tree-snakes, opossums, and other bird-eating creatures were abundant hereabouts, and for a colony of these conspicuous birds to conceal their nests successfully would be impossible. So their homes are swung out in full view of all. But, as we have seen, one or two precautions are always taken. Either the birds choose a solitary tree which fairly overhangs some thatched hut, or else the colony is clustered close about one of the great wasps' nests which are seen here and there high up among the branches of the forest.

The Indians and native Venezuelans never trouble the birds, which have been quick to realize and take advantage of this fact, and weave their nests and care for their young almost within arm's-reach of the thatched roofs. No monkey dares venture here, and the mongrel dogs keep off all the small nocturnal carnivores.

But a colony of cassiques which chooses to live in the jungle itself would have short shrift, were it not for the strange communal guardianship of the wasps. These insects are usually large and venomous, and one sting would be enough to kill a bird; indeed, a severe fever often ensues when a man has been stung by half a dozen. So the birds must be in some way immune to the attacks of the wasps. Perhaps their wonderfully complete armour of feathers, scales and horny beak accounts for this, while their quickness of vision and of action enables them

to save their eyelids—their one unprotected spot. Although the cassiques cannot have learned from experience of the terrible wounds which the wasps can inflict, yet they are keenly alive to the advantages to be derived from close association with them.

The wasps' nest is built far out on the tip of the limb of some forest tree, and the long pendant homes of the cassiques are placed close to it, sometimes eight or ten on the same branch, and others on neighboring limbs, so near that the homes of insects and birds rattle against each other when the wind blows.

One such community was placed rather near the ground, where we could watch the inhabitants closely. Frequently when one or two of the big birds returned to their nests with a rush and a headlong plunge into the entrance, the whole branch shook violently. Yet the wasps showed no excitement or alarm; their subdued buzzing did not rise in tone. But when I reached up and moved the branch gently downward, the angry hum which came forth sent me into the underbrush in haste. From a safe distance I could see the wasps circling about in quick spurts which meant trouble to any intruder, while the excited cassiques squeaked and screamed their loudest. Whether the slight motion I gave to the branch was unusual enough to arouse the insects, or whether they took their cue from the cries and actions of the alarmed birds, I cannot say.

The nests are beautifully woven of very tough palm-leaf shreds and grass stems, in shape like tall vases, bulging at the bottom to give room for the eggs and young birds, and with an entrance at the side near the top. We found still another instance of the unusual ability of these birds to adapt themselves to changing conditions. Those nests which were already deserted or with young ready to fly had simple rounded tops arching over to protect the entrance from the sun; but in the nests which were in process of construction, now at the beginning of the rainy season in early April, there appeared an additional chamber with a dense roof of thatch, in which one of the parents, the male in at least one case, passed the nights, safe from the torrents of sudden rain.

These cassiques seemed rather omnivorous, feeding on grubs, insects of all kinds, small fruits and berries.

The courtship display of the male, was to lower the head and neck, spread the tail, raise the yellow shoulders and fluff up the yellow feathers of the back and rump, thus bringing almost every bit of color into view at once.

The usual number of eggs seemed to be two. A typical nest collected from the colony at La Brea on April 11th contained

two eggs. It measures seventeen inches in length, with the entrance three inches in diameter. The neck narrows to two inches and the nest chamber at the bottom widens out to three again. The extra chamber at the top of the nest, is above and to the right of the entrance, about three inches high and deep, by five inches across. The nest lining is of very fine grasses.

The eggs are white, spotted, especially at the large end, with many small superficial dots, of various shades of brown, and a few large deeper stains of pale lavender. They measure 30 x 20 and 31 x 20 mm.

The communal condition of life existing between birds and wasps is probably of more general occurrence than we suppose. So persistent a habit of the yellow-backed cassique is this association with wasps, that it has been observed in many other places throughout Venezuela by Mr. Cherrie, and a group illustrating this communalism has been placed on exhibition in the Brooklyn Museum. The value to the wasp, if any, is unknown, but to the bird the association is of the greatest importance. In 1904 I described and illustrated a similar communal relationship in Western Mexico between the Sinaloa wren, *Thryophilus sinaloa,* and a wasp which built a single open comb nest.* In Savanilla, on the present trip, we observed in four instances, nests of two species, a thrasher and a wren, built within a foot of small, globular wasps' nests.

Mr. J. J. Quelch, in writing of this same species of cassique** says "It is a curious fact that almost invariably these nests are found built in the immediate vicinity of the nests of stinging ants and wasps which render them safe from molestation, though the insect homes are often so hidden that it is difficult to perceive them until the attempt to secure the birds' eggs has been made."

A similar intimate association with wasps has been reported of a South American flycatcher, of the Jamaican grassquit, *Euetheia olivacea olivacea,* and of the yellow oriole, *Icterus xanthornus.*

Icterus icterus (Linn.) TROUPIAL.

A pair of these birds spent several hours near our house at Guanoco on April 4th. They were of the rich orange type of color. One was secured and found to have been feeding on grubs. No others were seen during our stay.

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*"Two Bird-Lovers in Mexico," pp. 101-102.

**"Animal Life in British Guiana," p. 133.

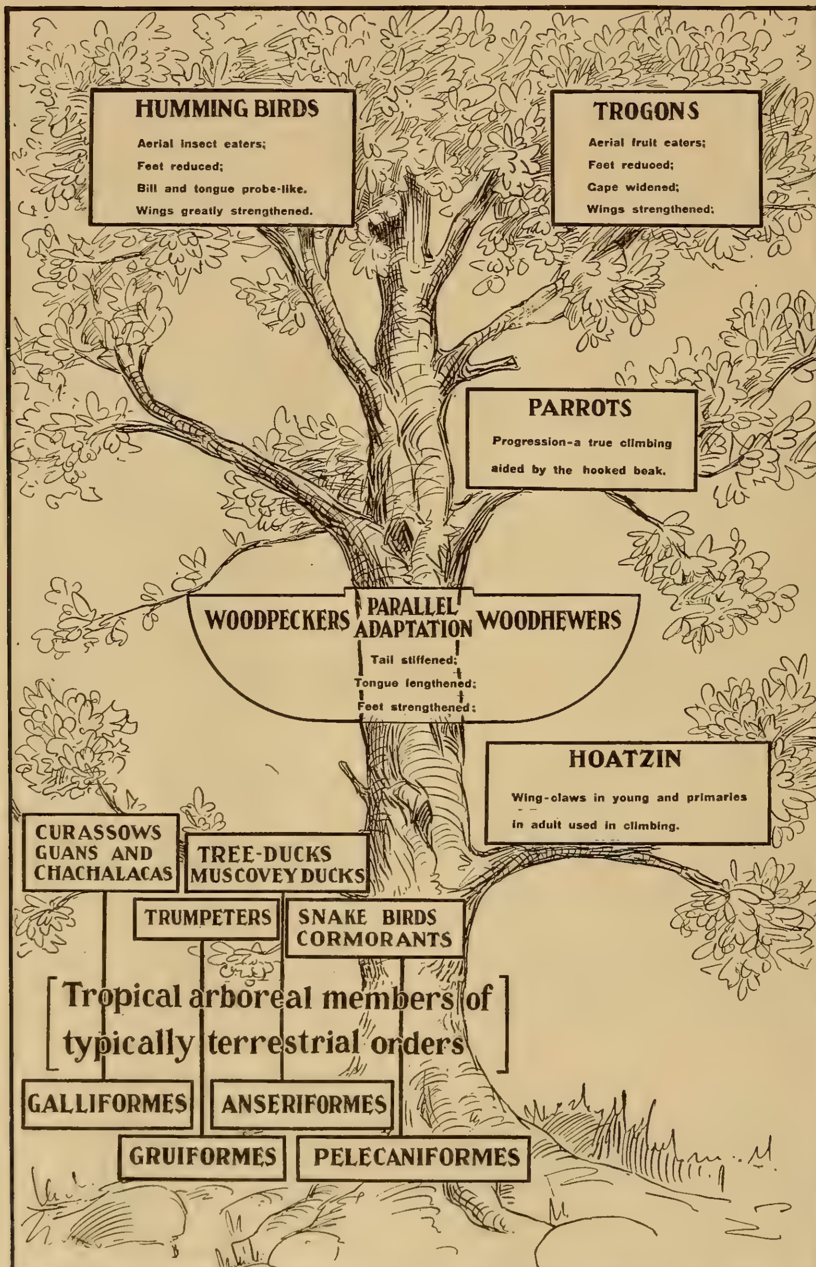

FIG. 37. Chart of Arboreal Adaptive Radiation.

Icterus chrysocephalus (Linn.). MORICHE ORIOLE.

We observed several specimens of this species flying about La Brea and saw several in captivity hung outside the huts of the Indians. The song is sweeter and more elaborate than that of the troupial.

Lampropsar tanagrinus guianensis (Cab.). CURLY-HEADED BLACKBIRD.

Common in small flocks all along the Rio Guarapiche and the Caño Guanoco. Very tanager-like in actions and call-note. They were feeding wholly on small insects.

PART V.

ECOLOGICAL CONCLUSIONS.

We have a fair knowledge of the external appearance of all the more important South American forms of bird life, although there are doubtless scores of species still to be discovered.

Of the ecology of the birds—in fact even the details of food and nesting habits of many of the species we know little or nothing.

In the twenty days at our disposal no more than a superficial glance at the bird life of the coast of Venezuela was possible. Many interesting facts came to our notice, however, and a few, incomplete as they are, seem of sufficient interest for present record.

The tropics present nature at her extreme development, the struggle for life is keener than elsewhere; the number of competing species much greater than in cooler latitudes. Hence a detailed study in this zone of adaptive radiation from the point of view either of structure or habits, will ultimately prove of the greatest value in throwing light on the processes of evolution.

Among the birds observed by us in Venezuela were several supposed to be peculiar to the Island of Trinidad, and Mr. Cherrie has taken one or two others far up the Orinoco. Owing to the occasional strong wind storms on the Gulf of Paria and the comparatively short distance between Trinidad and the mainland—varying from eighty to only seven miles—the occurrence of these insular forms at Guanoco is not remarkable.

In the area of mangrove swamp and coastal forest which we explored during the twenty days from March 25th to April 14th, we positively identified 138 species of birds, of which 22 species were breeding. This is between one-quarter and one-third, or

to be more exact 29.5% of the avifauna of the Orinoco region as given by Berlepsch and Hartert.* They give a list of 468 species and sub-species, and with the addition to this of 12 species new to this Orinoco region collected by Mr. Cherrie in 1907,* and 37 species from my list, we have a total, excluding 18 northern migrants, of 498 Orinocan birds. Disregarding the incompleteness of this list it is interesting to compare it, group by group, as a fair representation of the birds of the lower Orinoco region with the 244 species recorded as breeding in New York State.°

Glancing over the comparative table as a whole, we are instantly struck with the preponderance, in the Orinoco region, of birds of low type of organization.

Taking the two sections of Passeriformes as representing respectively higher and lower grades of development, we find the distribution thus:

Acromyodi (higher).

Of 18 families:
- 11 are more numerous in New York (6 being peculiar to the region).
- 1 is equally represented.
- 6 are more numerous in Orinoco (5 being peculiar to the region).

Mesomyodi (lower).

Of 6 families:
- All 6 are more numerous in Orinoco (5 being peculiar to the region).

*Mr. Cherrie's birds are as follows:

Heliornis fulica	Finfoot.
Himantopus mexicanus	Black-necked Stilt.
Ajaja ajaja	Roseate Spoonbill.
Mycteria americana	Wood Ibis.
Jabiru mycteria	Jabiru.
Zebrilis pumilus	Little Tiger Bittern.
Palamedea cornuta	Horned Screamer.
Sarcoramphus papa	King Vulture.
Catharistes urubu urubu	Black Vulture.
Rhyncocyclus sulphurescens	Sulphury Broad-bill Flycatcher.
Pitangus sulphuratus trinitatis	Trinidad Kiskadee Flycatcher.
Ramphocelus atrocericeus capitalis	Black-bodied Ramphocelus Tanager.

Of classical, isolated types of generalized structure we find more than half a dozen in the Orinoco region: *Tinamus, Opisthocomus, Psophia, Eurypyga, Aramus, Heliornis* and *Palamedea,*

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*On the Birds of the Orinoco Region, by Count Hans von Berlepsch and Ernst Hartert. Novitates Zoologicae. Vol ix, April, 1902, pp. 1-134.

°Check list of New York Birds, by M. S. Farr, 2nd edition. Bull. N. Y. State Museum. Vol. vi, No. 33.

while this argument is still further strengthened by the preponderance of such low orders as Galliformes and Columbiformes. This represents a splendid field of work for the embryologist, the comparative anatomist and the ecologist.

A more detailed comparison of the breeding birds of New York State with the birds of the Lower Orinocan region is given below. For the purpose of this table orders and families have both been used:

Groups Nearly Equal in Orinoco and New York.

	Orinoco.	New York.
Hirundinidae	6	6
Mimidae	2	3
Sylviidae	1	2
Fringillidae	26	22

Groups in Excess in Orinoco.

	Orinoco.	New York.
Galliformes	9	4
Columbiformes	11	2
Charadriiformes	9	7
Ardeiformes	22	6
Accipitriformes	21	13
Alcedinidae	5	1
Caprimulgidae	6	2
Cypselidae	3	1
Trochilidae	29	1
Cuculiformes	9	2
Picidae	20	9
Tyrannidae	71	9
Troglodytidae	10	5
Vireonidae	9	5
Tangaridae	26	1
Icteridae	18	9

Groups in Excess in New York.

	Orinoco.	New York.
Ralliformes	4	6
Lariformes	3	5
Anseriformes	5	9
Strigiformes	*5	7
Turdidae	5	7
Mniotiltidae	5	28
Corvidae	2	5

*I have added two species whose notes we heard.

Groups Absent from New York.

	Orinoco.
Tinamiformes	4
Opisthocomiformes	1
Gruiformes	3
Palamedeiformes	1
Pelecaniformes	2
Cathartidiformes	4
Psittaciformes	19
Trogoniformes	2
Motmotidae	2
Rhamphastidae	9
Capitones	2
Galbula and Buccos	12
Conopophagidae	1
Formacariidae	44
Dendrocolaptidae	27
Cotingidae	14
Pipridae	9
Coerebidae	10

Groups Absent from Orinoco.

	New York.
Podicipedidiformes	2
Colymbiformes	1
Ampelidae	1
Laniidae	2
Paridae	3
Sittidae	2
Certhiidae	1
Alaudidae	1

It is interesting to note in the case of certain groups of birds peculiar to one region that they are represented in the other region by groups paralleling them in function, thus supplying the gap left by their absence.

We noted the following examples of this, as apparent even in our brief review of the field:

Present in New York:	*Habits:*	*Represented in Orinoco by:*
Podicipedidiformes—Grebes Colymbiformes—Loons	Fish-eating divers	Heliornithidae—Fin-foot. Anhingidae—Snake-bird.
Laniidae—Shrikes	Non-accipitrine ornithophagous forms	Rhamphastidae—Toucans. Crotophaginae—Anis.
Sittidae—Nuthatches Certhiidae—Brown Creepers	Tree creepers	Dendrocolaptidae—Wood-hewers.

Among many interesting phases of the ecology of the birds suggested by the comparative tables, several may be tabulated, as at least giving material for consideration in future tropical field work.

Conditions in Orinoco.	*Conditions in New York.*	*Theoretical Effect On:*	*Actual Effect.*
Large number of nocturnal, aboreal, predatory mammals; more than twice as many as in New York.	A much less number of such mammals.	A—Number of Owl Competitors. B—Habits of Owls. C—Percentage of Nest Building in Holes.	A—5 Owls in Orinoco, 7 in New York (10 including migrants). Comparison is as follows: In Orinoco, 1 species of owl to every 100 species of birds. In New York, 1 species of owl to every 35 species of birds. B—40% of the Orinoco Owls are diurnal. No resident New York Owls are diurnal. C—*In Orinoco 30% of the birds nest in holes. In New York 18% of the birds nest in holes.
Jungle everywhere very dense; little undergrowth, little terrestrial fruit, berries and insect life.	Forest more open, varied with fields. Fruit, berries and insect life both terrestrial and arboreal.	Arboreal vs. Terrestrial Habits of Birds.	As regards fruit, berry and insect-eating birds: In *Orinoco* 8% of the birds are terrestrial. In *New York* 22% of the birds are terrestrial.
Excessive numbers of organisms, and keen struggle for life.	Less numerous organisms, less evident struggle.	Opportunity for Scavengers.	Avian scavengers absent in New York. Everywhere abundant in Orinoco of at least 6 species; 4 Cathartidiformes. 2 Accipitriformes.
Excessive continuous supply of insect food.	Less and seasonably intermittant supply of insect food.	Distribution of Insectivorous Birds.	In Orinoco 53% are insectivorous. In New York 27% are insectivorous. Unequal.
Supply of fruit, berries and seeds more equal in both regions.		Fruit, Berry and Seed Eaters.	In Orinoco 23% are fruit, berry or seed eaters. In New York 18% are fruit, berry or seed eaters. More evenly balanced.

*Percentage based only on birds regularly preyed on by small mammals and by owls.

The exclusively arboreal type of bird is so characteristic of the Orinocan region that it is worth while to examine it from the standpoint of adaptive radiation. We may illustrate the arboreal specialization by a diagram, the condition of each division of which offers a good field for future observation. (Fig. 37.)

We find *Opisthocomus*—a wholly arboreal form—confined usually to the lower branches. The Orders Galliformes, Gruiformes, Anseriformes and Pelecaniformes, which, in more temperate zones are chiefly terrestrial, are predominantly arboreal in the Orinoco region.

Ascending the trunks of the trees we find two dominant groups, exhibiting parallel specialization—the woodpeckers and the woodhewers. Confined to the higher branches and especially adapted to a scansorial life, we have the great groups of parrots; while hummingbirds and American trogons are adapted for aerial feeding, obtaining insects in the one case, and fruit in the other, from the branch tips.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
NEW YORK ZOOLOGICAL SOCIETY

VOLUME I, NUMBER 4.

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COLLECTED BY C. WILLIAM BEEBE IN SOUTH AMERICA

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BY VERNON L. KELLOGG

II. A NEW MANTIS FROM BRITISH GUIANA

BY A. N. CAUDELL

III. NEW SPECIES OF LEPIDOPTERA FROM BRITISH GUIANA

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NEW SPECIES OF INSECTS

COLLECTED BY C. WILLIAM BEEBE IN SOUTH AMERICA

Among the small collection of insects which I brought back from Venezuela and British Guiana, a number proved to be new to science. These have been kindly described for me by Prof. Vernon L. Kellogg, Mr. A. N. Caudell and Dr. Harrison G. Dyar.

There are two new Mallophaga, one new Mantis, and twenty-five new species, including six new genera of Moths.

In a future scientific contribution to the Avifauna of these countries I will have occasion to refer to many of these insects as forming the food of certain birds. *C. W. Beebe.*

I.

MALLOPHAGA FROM THE HOATZIN

(*Opisthocomus hoazin*).

By Vernon L. Kellogg, Stanford University, Calif.

By the kindness of Mr. C. William Beebe of the New York Zoological Park I have had the opportunity of examining a few specimens of Mallophaga taken from the Hoatzin (Venezuela). This curious bird, the single species of the pheasant-like, although strongly aberrant family Opisthocomidae has for long been a taxonomic puzzle to the ornithologists. It has been with unusual interest, therefore, that I have examined these specimens of their parasites. Although many of the Mallophaga are rather catholic in their host likings some of them keep pretty strictly to special bird groups. This is especially true of the parasites of the Pheasants, the Phasianidae having their own types of Mallophaga more conspicuously, perhaps, than any other bird group. If then the Hoatzin is truly a close relative of the Pheasants, as ornithologists seem to think, this fact might, perhaps, be indicated by the affinities of its parasites.

As a matter of fact this lead starts admirably. For one of the three species taken from the Hoatzin by Mr. Beebe belongs to a characteristically pheasant-infesting genus. This parasite is *Goniocotes curtis* which Nitzsch (the first student of the Mallophaga) took from a Hoatzin over fifty years ago, and which has not been recorded from any other host since. Of the fifty-six species of Goniocotes known, practically all are recorded only from the Pheasants and Pheasant-like birds.

But the other two species of Mallophaga from the Hoatzin that are represented in Mr. Beebe's collection are unfortunately new species and species belonging to groups without any such *penchant* for a particular host group. One of these, however, a *Lipeurus*, belongs to the group *clypeati sutura distincta* which is composed of species so far practically limited to such strictly

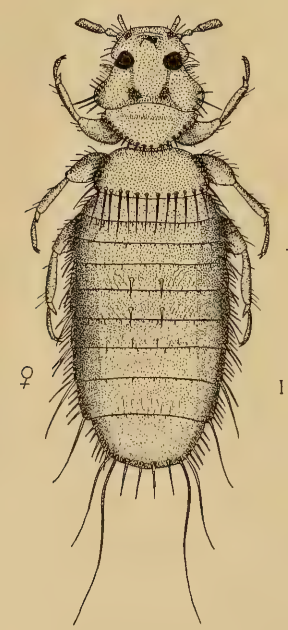

Fig. 38. *Colpocephalum armiferum,* new species.

maritime birds as Albatrosses, Cormorants, Boobies and Pelicans. The other new species is a *Colpocephalum* with two of its nearest forms (*spinulosum* and *spineum*) also from maritime or shore birds. *C. spinosum,* a third related form, is, however, a Francolin (African Partridge) infesting species.

Thus there is nothing too definite about the taxonomic indications to be derived from the Hoatzin's Mallophagan parasites. *Unless the Lipeurus could be a straggler from some maritime bird species!* Mr. Beebe informs me that there has been no opportunity for such straggling; either normal (that is, from approach of the hosts in nature) or abnormal (that is, from approach of the host bodies in live cage or game bag or on the work table).

The descriptions of the two new species follow:

Colpocephalum armiferum, new species. (Fig. 38.)

One male and three females taken by C. Wm. Beebe from the Hoatzin, *Opisthocomus hoazin,* (Venezuela).

A *Colpocephalum* of general likeness to *C. spinosum* from the African Partridge, *Francolinus capensis,* and to *C. spineum* from various maritime birds and *C. spinulosum* from shore birds. But this species from the Hoatzin is quite distinct from any of these forms and in its possession of an extraordinary thorniness of thorax and abdomen stands well apart from any other species in the genus.

Female, body, length 1.7 mm.; width, .58 mm.; many stout, pointed spines along the lateral margins and on the posterior borders of prothorax and metathorax; unicolorous pale golden, except for two strong blackish-brown ocular blotches and less distinct and large occipital and clypeal blotches.

Head, length, .36 mm.; width, .45 mm.; the usual marginal hairs all of the character of spines. Prothorax with a series of short, stout spines along the posterior border; metathorax with a series of large conspicuous spines along the nearly straight posterior margin, and with spines on the posterior halves of the lateral margin. Shorter but conspicuous spines along the lateral margins of the abdominal segments with longer spines and hairs on the last two segments.

Male, body, length 1.6 mm.; width, .51 mm.; head, length, .33 mm.; width, .43 mm.; a little darker golden in color than female, with the brown blotches of the head a little more pronounced. Last abdominal segments without flexible hairs but with lateral margins and posterior margin of last segment with strong spines. The strongly chitinized genitalia show plainly through the body wall in the single male specimen I have.

Lipeurus absitus, new species. (Fig. 39.)

One male and two females taken by C. Wm. Beebe from the Hoatzin, *Opisthocomus hoazin,* (Venezuela).

This new *Lipeurus* of the group *clypeati sutura distincta* (all the other members of which have been taken from strictly

maritime and coast birds) is thoroughly distinct from the other species of the group. The unusual disproportion in length between the head and the rest of the body give it an odd large-headed appearance.

Male, body, length, 2 mm.; width, .55 mm.; with strong median dorsal blotches on the short abdomen; head and thorax with colored lateral margins.

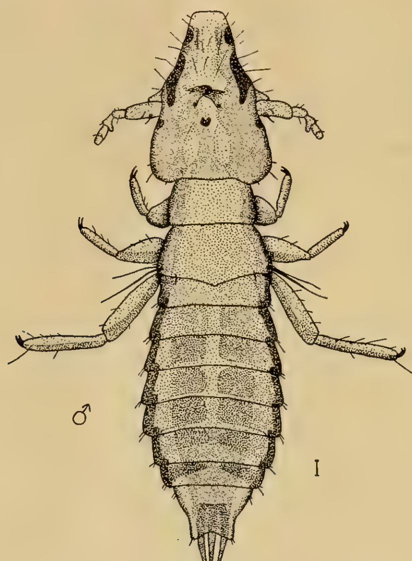

Fig. 39. *Lipeurus absitus,* new species.

Head, length, .7 mm.; width, .5 mm.; clypeal front flatly convex with distinct clear margin beyond the signature, which is distinct; strongly colored lateral clypeal bands distinctly interrupted by a suture, and with the ends expanding inwards; a few conspicuous hairs along lateral clypeal margins; temples not strongly expanded, nor temporal angles produced; antennae with enlarged first segment without appendage but with a short hair on a slight swelling, third segment with well-marked lateral process. Head unicolorous except for the darker clypeal bands and signature.

Prothorax small and with lateral and posterior margin straight; metathorax with very obtuse but distinct median angle on the posterior margin; two or three longish flexible hairs in posterior lateral angles. Fairly unicolorous golden brown.

Abdomen with distinct median brownish blotches; sparse hairs on dorsum and a few short spine-like hairs in posterior angles of each segment; lateral borders chitinized but not strongly colored. Last segment with marked concavities on the lateral margins and with strong posterior angles; only a few short hairs.

Female, body, length, 2.43 mm.; width, .76 mm.; head, length, .7 mm.; width, .51 mm.; abdomen markedly broader and heavier than in male; the median dorsal abdominal blotches are divided in the middle and extend laterally nearly or quite to the chitinized lateral borders; in the median longitudinal clear space there are two distinct longish hairs on the dorsum of each segment; last abdominal segment is much narrower than the next to last, and is all brown; it has slight concavities in its lateral margins just in front of the posterior angles.

II.

A NEW MANTIS FROM BRITISH GUIANA.

BY A. N. CAUDELL, U. S. Nat. Museum, Washington, D. C.

Among some interesting Orthoptera recently determined for Mr. C. W. Beebe, Curator of Birds in the New York Zoological Park, and collected by him in British Guiana in February, 1908, was a species of *Stagmomantis* of which I can find no description. It may be characterized as follows:

Stagmomantis hoorie, new species. (Fig. 40.)

1 ♂, 1 ♀, British Guiana, near the Hoorie gold mine on Hoorie Creek, a tributary of the Barama River. C. William Beebe, collector.

Stands intermediate in size between *fraterna* Sauss. & Zehnt., and *theophila* Rehn and is allied to these forms. The pronotum is slender and sparsely but distinctly armed laterally with blunt teeth or tubercles. The anterior coxae are black apically on the inner side and the adjacent part of the fore femora is similarly colored; the inner face of the fore femora

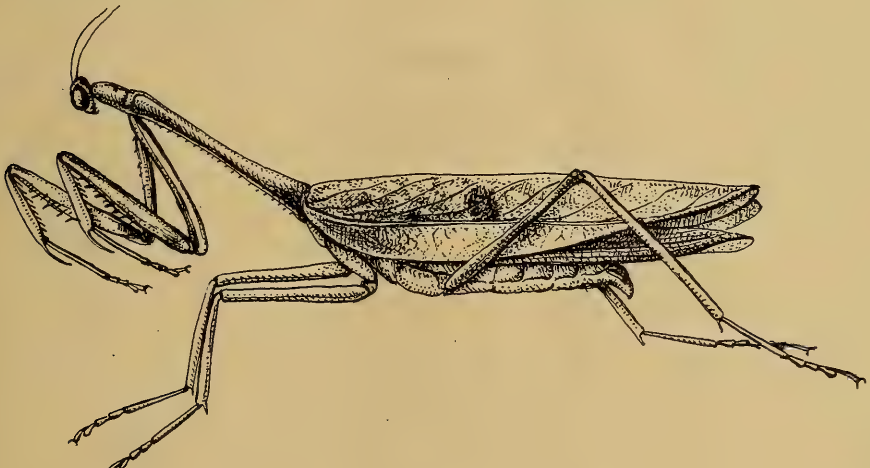

FIG. 40. *Stagmomantis hoorie,* new species.

is also marked with a small black patch, almost obsolete in the female. The wings of both sexes reach well beyond the tip of the abdomen; the elytra of the male are without stigma or colored or coraceous costal margin, and the wings are wholly hyaline except for an almost imperceptible dark tinge apically; in the female the elytra are green with rounded brownish stigmae, the anal field transparent for most its length and the costal field about one-fourth as broad as the entire elytral width; the wings of the female are hyaline with the tips tinged with green and the rest deeply marked with yellow. The elytra of both sexes fail to reach the tip of the wings when at rest, in the male lacking about four millimeters.

Length: pronotum, ♂, 15 mm., ♀, 18.5 mm.; fore femora, ♂, 10 mm.; ♀, 12 mm.; elytra, ♂, 25 mm.; ♀, 28 mm.; Width: pronotal dilation, ♂, 2.5 mm.; ♀, 3.5 mm.; costal field of elytra at widest part, ♂, 1.5 mm.; ♀, 2.5 mm.

Catalogue No. 12815, U. S. Nat. Museum.

Another interetsing species from the same locality is *Moncheca nigricauda* Stål, a locustidian described from an unknown locality and since unrecorded.

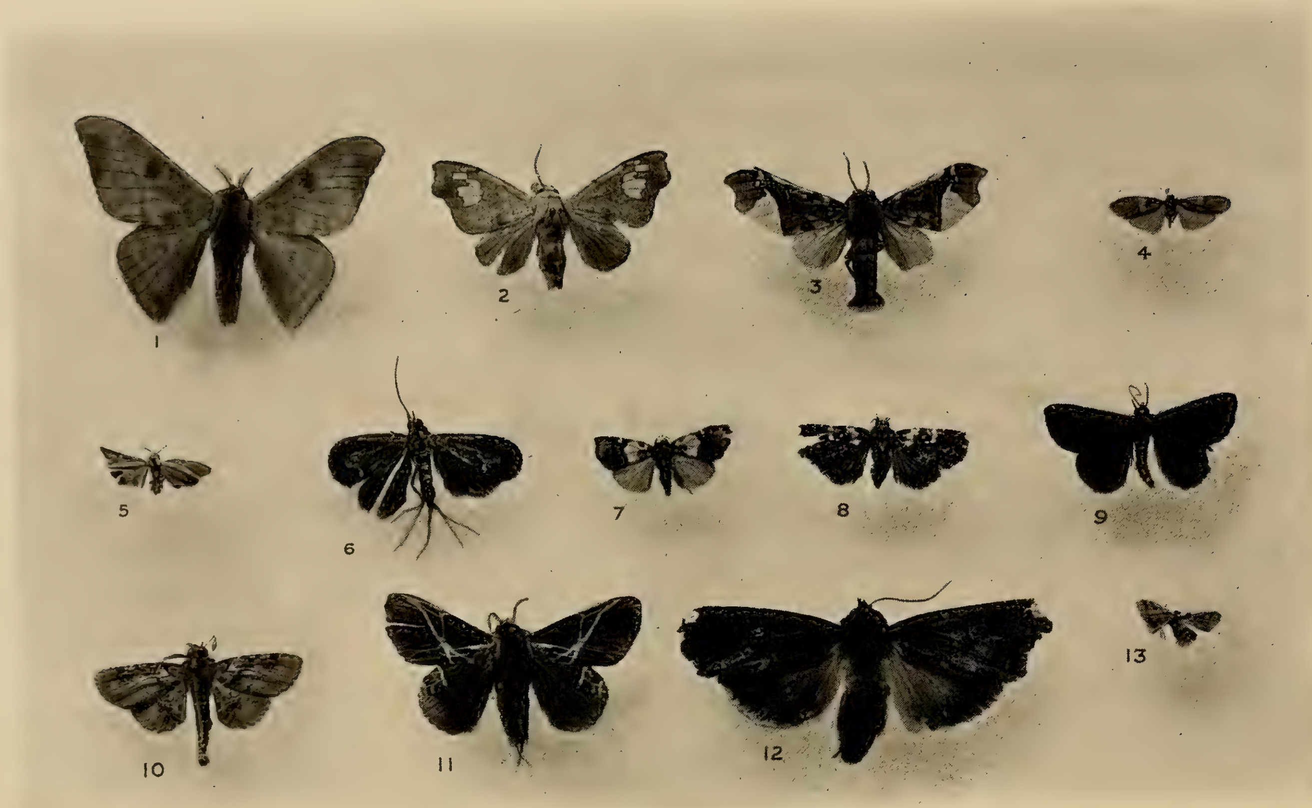

Fig. 41. New Lepidoptera from British Guiana.

III.

NEW SPECIES OF LEPIDOPTERA FROM BRITISH GUIANA.

BY HARRISON G. DYAR, U. S. Nat. Museum, Washington, D. C.

The following new species occurred among a collection of Lepidoptera made by Mr. C. W. Beebe, Curator of Birds in the New York Zoological Park, in British Guiana in February, 1908.

FAMILY *SATURNIIDAE.*

Hylesia indurata, new species. (Fig. 41, No. 1.)

♂. Antennae yellowish brown; thorax dark brown in the middle, the patagia light purplish; abdomen with numerous yellow hairs above, reddish below, the segments showing dark brown at their bases. Fore wing with the apex acute, subfalcate. Purplish, with a frosty tint, the markings dark purplish brown; a shade on the inner margin at base, indicating the inner line; discal mark large, round, clouded; outer line narrow, straight, more obscure above, especially toward the costa where there is a small shade; a large terminal blotch below the apex. Hind wing with two outer lines, the subterminal one broader. Expanse, 33-43 mm.

♀. Fore wing acute at apex, but not subfalcate. Colors as in the male, but more shaded; discal mark large, transverse; two outer lines, both broad, the subterminal the broader, much as on the hind wing. Expanse, 55 mm.

One ♂, Hoorie,* British Guiana (C. W. Beebe); 10 ♂ ♂ St. Jean, Maroni River, French Guiana, July, 1904 (W. Schaus); 1 ♂, Geldersland, Surinam River, Dutch Guiana (W. Schaus); 1 ♀, St. Jean, French Guiana, July, 1904 (W. Schaus).

Type.—No. 12634, U. S. National Museum.

*Hoorie Gold Mine, on the Hoorie Creek, tributary of the Barama River, British Guiana.

FAMILY *ARCTIIDAE.*

Zatrephes cardytera, new species. (Fig. 41, No. 2.)

Head and thorax clay-colored, finely irrorate with red-brown; abdomen with a dull red patch in the middle. Fore wing broad, with a prominent rounded angle on the outer margin at veins 4-6. Clay-colored, irrorated with red specks toward the base and olivaceous ones outwardly. A series of rounded hyaline spots between the veins from vein 3 to the subcosta; the three lower ones are confluent, the upper of the three shorter than the others and just at its end is the fourth spot, between veins 6-7; above the base of this last is a small spot. A brown cloud occupies the space between the larger hyaline spots and the margin. An olivaceous spot on the inner margin indicates an inner transverse band, which is continued in the cell to costa; an olivaceous costal mark at the outer third. Fringe narrowly white below the marginal protrusion. Hind wing ochraceous-crimson except along the costal margin, where it is clay-colored. Beneath clay-colored, the hyaline marks of the fore wing repeated. Expanse, 33 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12656, U. S. National Museum.

Allied to *Zatrephes trilineata* Hampson and *Z. flavida* Hampson, but with larger and more hyaline spots than any species of the genus.

Zaevius, new genus.

Fore wing with vein 2 from before the angle of the cell, 4-5 separate at origin, 6-10 stalked, 10 from beyond 7, 11 from cell; hind wing with vein 2 from well before angle of cell, 3-5 stalked, 4 absent, 6-7 coincident, 8 from before the middle of the cell. Palpi upturned, reaching beyond the middle of the front, the third joint minute. Spurs of the hind tibiae moderate. Male antennae shortly pectinate. Fore wing with the outer margin roundedly excised below the apex.

Zaevius calocore, new species. (Fig. 41, No. 3.)

Head, thorax and abdomen ocher with a brown tint, the abdomen with a spreading anal tuft of the same color; orbits beneath crimson; venter pink, the legs of this color except the tarsi, which are white. Fore wing with a large, triangular, whitish, subhyaline patch on tornus, reaching to vein 5, sending a point to vein 6, and a small detached spot between veins 7-8. Basally of this mark brown with slight ocher admixture, two

angular pink marks on inner margin, one near base of costa nearly crossing wing and irregular markings in the cell outwardly to the small subhyaline dot; a long white mark on costa and a bar just before the small dot. Apex ocher, crossed by brown veins. Hind wing subhyaline white, the inner margin broadly and minute discal dot pink; costal margin ocher. Beneath the fore wing has the subhyaline mark repeated, base orange-red, costa purplish, apex ocher as above. Expanse, 47 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12657, U. S. National Museum.

Family *LITHOSIIDAE.*

Thyonæa, new genus.

Structure and venation of *Thyone* Walker, but vein 6 of the fore wing stalked with 7-9.

Type, *Thyone perbella* Schaus.

Thyonæa dremma, new species. (Fig. 41, No. 4.)

Head yellow; thorax orange brown; abdomen pale yellow. Fore wing orange yellow; a broad median stripe of this color edged on each side with a purplish shade. Veins in the basal and apical areas lined with red. Hind wing yellow with a slight fuscous tint. Expanse, 17 mm.

One ♂, Hoorie British Guiana (C. W. Beebe).

Type.—No. 12658, U. S. National Museum.

Allied to *Thyonæa perbella* Schaus, but the veins are lined with red instead of blackish and the median band is broader, with its edges less parallel.

Illice biota, new species. (Fig. 41, No. 5.)

Head gray, yellowish around the margins of the vertex and base of antennae. Tegulae yellow, shading to red in front. Thorax gray, the patagia yellowish within. Abdomen crimson, with long lateral and terminal tufts. Fore wing slaty gray, a broad pale yellow stripe along submedian fold from base to termen. Hind wing with the margin strongly emarginate in the middle between the submedian fold and vein 3, the anal angle rounded. Pale crimson, the apex broadly gray. Expanse, 15 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12659, U. S. National Museum.

Allied to *Illice minuta* Butler, but with the stripe on the fore wing much broader. *Illice minuta* is known in a single female

from Colombia and may possibly be the other sex of the present species. These two species should probably form a distinct section of the genus, as it is probable that *minuta* has in the male the same emargination on the outer edge of the hind wing as in the present species.

Family *NOCTUIDAE*.

Subfamily *Acronyctinae*.

Neophænis ædemon, new species. (Fig. 41, No. 6.)

Palpi with the third joint long. Head, thorax and fore wings green, variegated with black markings. Fore wing with the ordinary lines geminate, lunulate, the outer line sharply so above, filled above, followed below by white; reniform and orbicular large, doubly black ringed; subbasal line faint, geminate; a black blotch on inner margin across vein 1; a mark on costa mesially, a bar in cell and a blotch on inner margin from vein 2 next to the outer line; a series of subterninal nearly confluent black spots, between which and the margin is a black shading interrupted mesially; a terminal broken black line; fringe spotted with black. Hind wing black with some green above tornus and on fringe. Legs long, pale brownish, the fore legs green and banded with black. Expanse, 30 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12671, U. S. National Museum.

Emarginea empyra, new species. (Fig. 41, No. 7.)

Head white, thorax black with a red-brown tuft behind; abdomen black above, white below, the anal tuft white. Fore wing with the basal half white, a quadrate clay-colored mark basally on inner margin, edged with a fine black line that is thickened at base; a small costal mark similarly bordered with black. A black line limits the white field, slightly inflexed below cell, expanded on costa and including a small white spot. Terminal half of wing brown, with a purplish luster at apex and tornus, dull centrally. A minute white speck on costa before apex. Hind wing soiled whitish, shaded with fuscous on costa and inner margin. Expanse, 17 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe); 2 ♂♂, St. Jean, Maroni River, French Guiana, March, 1904 (W. Schaus).

Type.—No. 12672, U. S. National Museum.

Hadena niphetodes, new species. (Fig. 41, No. 8.)

Blackish gray with olivaceous shadings. Scales of the thorax very long and spatulate. Fore wing with a broad white band from costa to vein 1 at basal third, edged with black, but not sharply relieved against the general dark color of the wing. Orbicular small, white. Reniform pure white, more or less distinctly joined to costa by a white or olivaceous patch, its lower angle produced inward or detached as a small dot. Outer line black, scarcely relieved, single, crenulate. Subterminal line marked by white or olivaceous spottings. A black terminal line, the fringe slightly intermixed with whitish. Hind wing black, the fringe intermixed with white. Beneath black, frosted with white, especially on hind wing, which has a dark discal annulus and outer line. Expanse, 23 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe); 1 ♀, St. Jean, Maroni River, French Guiana, July, 1904 (W. Schaus).

Type.—No. 12673, U. S. National Museum.

I have placed this species in "*Hadena*" because the genus in which it falls (the tenth genus on page 13 of vol. viii of Sir G. F. Hampson's "Catalogue of the Noctuidae in the collection of the British Museum") appears not to have been validated by the citation of species under it, and I therefore avoid publishing it in advance of the author's action.

Subfamily *Noctuinæ.*

Capnodes albicosta, new species. (Fig. 41, No. 9.*)

Head and collar black, with a slight white frosting, especially on posterior edge of collar; thorax rust-red; abdomen blackish. Fore wing rust-red with blackish tint, the costa narrowly yellowish white, ordinary lines slender, blackish the outer with points on the veins, the median space solidly filled with blackish up to the cell and around its end to vein 6. Reniform represented by two separated dots, which, with the orbicular, have small white centers in black annuli. Traces of subterminal line. Fringe blackish, cut by rust-red at the ends of the veins. Hind wing with the mesial area faintly black-shaded as on fore wing, the traces of subterminal line and fringe similar. Beneath dull-colored, thickly irrorated with blackish, the hind wing with blackish discal mark and mesial dentate line. Expanse, 27 mm.

*The photograph is too dark and does not show the markings.

One ♂, Aremu, Little Aremu River, tributary of the Cery-inyi River, British Guiana (C. W. Beebe).

Type.—No. 12674, U. S. National Museum.

Thermesia dorsilinea, new species. (Fig. 41, No. 10.)

Body purplish, darkest on thorax, a continuous dorsal clay-colored line from head to tip of abdomen. Wings purplish, the fore wing with a broad inner band of clay-color shaded with brown, especially on its margins and containing a clearer line in its outer third. The band expands in the cell and confusedly joins a similar costal patch at the end of the cell, through which the outer line runs, clay-colored, angled at vein 6, expanding a little and marked with brown below vein 1. Traces of submarginal line, whitish, waved, placed far from the margin. A row of minute terminal black dots. Hind wing with a broad mesial band of mixed brown and clay-color, distinct on the inner two-thirds and centered by a brown line in a clearer field. A reniform annular discal mark. Terminal area as on fore wing. Expanse, 27 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe); 1 ♂, Rockstone, Essequebo River, British Guiana, September, 1904 (W. Schaus).

Type.—No. 12675, U. S. National Museum.

The second specimen has been labelled by Mr. Schaus "not in the British Museum."

Family *LASIOCAMPIDAE.*

Claphe laudissima, new species. (Fig. 41, No. 11.)

Dark brown, collar and patagia broadly lined with creamy yellow; abdomen lighter brown. Fore wing dark brown, with a slight bronzy tint, a white streak at the base along submedian fold to near the middle of the wing. Costa narrowly creamy yellow from the base to near apex; a straight creamy yellow line crosses the wing from costa near apex to middle of inner margin; a second narrower one starts on the middle of the costa, curves to touch the outer line below the middle of the wing and reaches the inner margin near the base; a yellow streak between these lines above the subcostal vein. A narrow waved subterminal line, incurved opposite the cell, inwardly dentate on vein 3, running inward on vein 2 nearly to the transverse line, and along vein 1 to the base. Hind wing with the costal third dark brown with a distinct white streak at the outer third and beyond it some

broken white lines; the rest of the wing a little lighter brown and without markings. Beneath light brown, without markings. Expanse, 37 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12654, U. S. National Museum.

From the description, this appears nearly allied to *Hydrias laudia* Druce, from Ecuador. Possibly it is the same species, but a number of the finer markings are not mentioned in Druce's description, while the two localities are rather remote. I therefore provisionally consider the species distinct.

Family *NOTODONTIDAE.*

Rifargia phanerostigma, new species. (Fig. 41, No. 12.)

Head and thorax dark brown, a little intermixed with lighter tints; abdomen brown-gray, the segments lighter at the tips, a yellow lateral tuft at each side at base, the second segment brown at tip. Fore wing dark brown, the basal and terminal areas with a chocolate-brown tint, the middle field more grayish, but dark and nearly uniform. The basal space has a transverse strigose appearance and is limited by the inner line, which is geminate and chocolate-brown filled. Median space rather narrow, narrower on the internal margin than on the costa, containing the elliptical discal mark, which is composed of an outer, broken white ring, faintly bordered within by a narrow brown line, and centered in its lower half by an ocher-yellow dot. Outer line similar to the inner, the terminal space with transverse indistinct striation, the subterminal line fine, pale, irregular, broken, forming minute white dots on the veins and yellowish dashes between them. A submarginal row of intravenular dots, their outer halves dark brown, their inner, yellow-white. An apical rounded, pure white blotch. Hind wing dark brown with the fringe yellowish white except just beyond anal angle. Expanse, 53 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12640, U. S. National Museum.

Only the female is before me, but I think that the generic reference is correct. The species is closely allied to *Rifargia occulta* Schaus and *R. onerosa* Schaus; but neither of these possesses the clear white apical mark on the fore wing, besides other less striking difference.

FAMILY *GEOMETRIDAE.*

Subfamily *Sterrhinae.*

Eois costalis, new species. (Fig. 41, No. 13.)

Brownish ocher or clay color. Collar and costal margin of fore wings to outer third dull crimson. Fore wings crossed by four rather broad dull crimson slightly waved bands, the fourth submarginal and the narrowest, not attaining the apex. Fringe concolorous with wing, but blackish at anal angle. Hind wing with four broad bands like the fore wing, the first nearly basal, the submarginal one as broad as the others, but narrowing toward anal angle. Beneath suffused with crimson, the bands nearly lost. Expanse, 12 mm. The antennae have very long cilia.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12670, U. S. National Museum.

Subfamily *Geometrinae.*

Racheolopha nivetacta Warren. (Fig. 42, No. 14.)

Female.—Nearly twice the size of the male. Coloration in general similar, but the white fields of both wings broader, the green marginal areas reduced. The white is clearer, more opaque, while the dark strigae are larger and sparser. Abdomen green above, white below, the dorsal series of tufts brown as in the male. Expanse, 40 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

The species was described from a single male from French Guiana (Proc. U. S. Nat. Mus., xxx, 425, 1906).

FAMILY *PYRAIDAE.*

Subfamily *Chrysauginae.*

Acropteryx opulenta, new species. (Fig. 42, No. 15.)

Head, thorax green, the patagia tipped with chocolate brown. Fore wing bright green, crossed by two scalloped, broken brown lines. A large brown patch runs along the base of the costa, spreads out to fill the space between the lines down to vein 2 and crosses the outer line for a short space. Interspaces between vein 2 and the cell filled in with yellow, both within and without the outer line. Hind wing whitish, the margin narrowly roseate. Expanse, 42 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

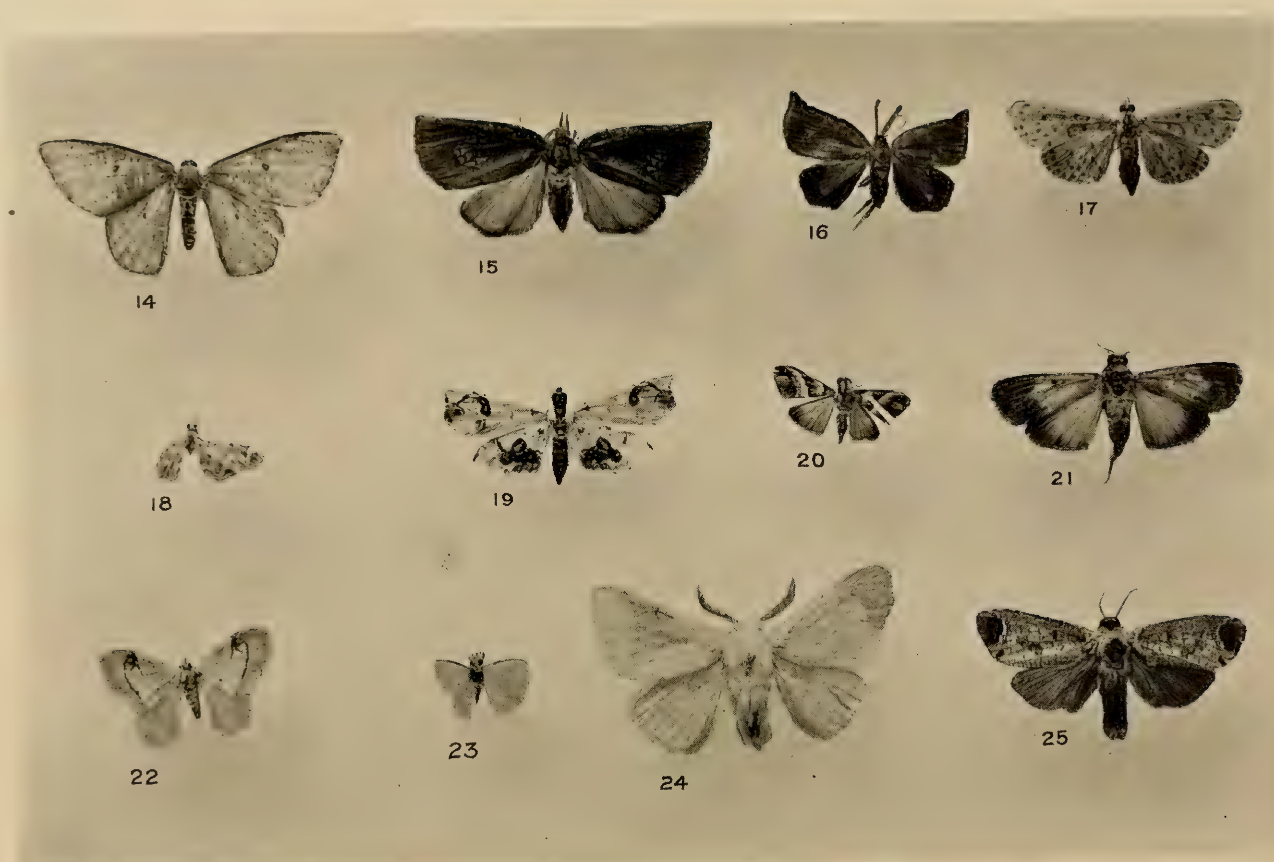

Fig. 42. New Lepidoptera from British Guiana.

Type.—No. 12660, U. S. National Museum.

Apparently allied to *Acropteryx arnea* Cramer, which is not before me. The present species, however, has no yellow at the base of the wing as in Cramer's figure, while the outer yellow is here placed close to the edge of the marking instead of near its center.

Saccopleura lycealis, new species. (Fig. 42, No. 16.)

Palpi dark brown. Thorax and abdomen olivaceous brown. Fore wing olivaceous, the costa narrowly bright brown. Lines faint, far apart, pale, the inner a faint trace only, the outer faint, straight. A bright white speck on the costa at the emargination. Inner area of the wing and fringe shaded with purplish. Hind wing with the disk yellow, the costa, outer margin and inner margin broadly black. Beneath the fore wing has the basal field yellow, costa and outer margin broadly dark. Expanse, 26 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12661, U. S. National Museum.

Similar to *Saccopleura catocalis* Ragonot, but the yellow of the hind wing forms a narrow central area, as in some species of *Lyces* before me.

Subfamily *Pyraustinae.*

Dichocrocopsis, new genus.

Palpi porrect, exceeding the front by more than the length of the head, the second joint thickly but closely scaled, the third naked and bent downward. Maxillary palpi minute. Tongue well developed. Hind tibiae with the spurs long. Fore wing with veins 3-5 arising near the end of the cell, 4 and 5 appromimated at origin, 7 from below upper angle of cell well separated from 8-9, which are stalked, 10, 11 from the cell. Hind wing with 3-5 from near angle of cell, 3-4 approximated at origin, 6 from upper angle of cell, 7 anastomosing with 8.

Dichocrocopsis maculiferalis, new species. (Fig. 42, No. 17.)

Dark ocher yellow, with many rounded brownish black spots; a spot on each side of front below; abdomen with spot on second segment and subdorsal and lateral rows; venter and legs white. Fore wing with three spots in cell and three below on submedian fold, also three smaller ones on inner margin; two spots between veins 2-4 at base; an outer row of seven, excurved below cell; a submarginal row of six and a marginal row. Hind wing with

a spot in cell, a mesial row somewhat irregular in course, three spots beyond cell, a submarginal and a marginal row. Expanse, 34 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12665, U. S. National Museum.

Ischnurges bicoloralis, new species. (Fig. 42, No. 18.)

Palpi slightly curved upward, all the joints evenly fringed with scales below, white, banded with ocher. Body, legs and wings marked with white and ocher. Fore wing shining white; subbasal and inner blotches cut into angular segments by the white ground, not attaining costa; a blotch below cell, joining a longitudinal one at end of cell, which touches the narrow erect outer line, and is cut longitudinal by white above vein 5; a blotch on inner margin just within the outer line; a large blotch on outer margin, not attaining the edge; fringe ocher at base, white without. Hind wing with mesial and outer broad bands of ocher, produced outward submedianly; a subapical patch, not attaining the margin and continued narrowly toward anal angle; fringe as on fore wing. Beneath with a fuscous tint, the markings partly repeated in pale fuscous. Expanse, 20 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12666, U. S. National Museum.

Subfamily *Schœnobiinæ.*

Hositea, new genus.

Palpi porrect, exceeding the front by about half their length, the second joint roughened with scales below, the third distinct. Maxillary palpi thicker and stouter than the labial palpi, considerably longer than those and with rough squamose vestiture. Tongue very short, curled but not long enough to form a spiral. Antennae flattened, lamellate, similar in the sexes. Spurs of the tibiae long. Fore wing with vein 2 from beyond middle of cell, 3-5 close together from near lower angle of cell, 6 from below upper angle, 7 from angle of cell or very shortly stalked, 8-9 stalked, 10 and 11 from the cell. Hind wing with vein 2 towards end of cell, 3 from the angle, 4-5 slightly above angle and approximate at base, 6 from upper angle of cell, 7 anastomosing with 8. Fore wing pointed at apex, the outer margin roundedly produced in the middle; hind wing with a sharp point at the end of vein 7 and slight points at veins 2 and 4.

I have placed this genus in the Schœnobiinæ on account of the smallness of the tongue; but whether here or in the Pyraus-

tinae I know of no other genus with the maxillary palpi so relatively large and exceeding the labial palpi.

Hositea gynæcia, new species. (Fig. 42, No. 19.)

Shining white. Palpi largely black with small white rings only; vertex of head black; disk of thorax black; abdomen with two black spots at the base, a square brown patch on the third segment and part of the second, the fifth to seventh segments metallic black dorsally. Venter and legs white, without markings. Fore wing with some of the scales near the base tipped with brown, forming a small patch; traces of an inner line, showing as some brown scales in the submedian fold; discal mark large, black, centered with a fine blue line with diffused blue scales about it, elliptical and close to the costa in the male, reniform and more distant from the costa in the female; outer line black, starting on costa above discal mark, outwardly oblique to vein 6, bent sharply inward, lost between veins 2 and 4, reappearing below 2, more brownish with a sharp outward bent on submedian fold. A brown cloud shaded with orangle scales at the marginal expansion of the wing and a smaller one at the lower projection of the outer line. A row of terminal black marks, distinct on the upper half of the wing. Hind wing with subbasal marking like fore wing. Discal spot round, large, circled with dark brown, with a yellow eccentric spot, impressed into the mesial line and brown in color in the male, more prominent and dark yellow in the female. Mesial line black costally, brown below, closely followed by a large brown patch, in which are intermixed purple scales in the female only opposite the discal mark. A narrow black line parallel to the irregular termen, the terminal space near anal angle filled in with yellow. Black terminal marks on the projections of the wing. Expanse, 20-34 mm.

Two ♂♂, 1 ♀, Hoorie, British Guiana (C. W. Beebe); 1 ♂, St. Jean, Maroni River, French Guiana, July, 1904 (W. Schaus).

Type.—No. 12664, U. S. National Museum.

Subfamily *Epipaschiinæ.*

Incarcha, new genus.

Palpi upturned far above the vertex of the head, smooth, terete, the third joint lanceolate, in the male hollowed on the inner side to receive the long double hair-pencil of the maxillary palpi. Antennae simple in the female, fasciculate in the male with a long basal process reaching back to the end of the thorax,

clothed on the sides with very broad curved scales. Fore wing with vein 3 from before angle of cell, 4 and 5 approximate towards base; 6 from upper angle of cell, 7-9 stalked, 10 and 11 from the cell. Hind wings with veins 4 and 5 approximate near origin, 7 anastomosing with 8.

Incarcha aporalis, new species. (Fig. 42, No. 20.)

Fore wing purplish brown shaded with olivaceous, with two broad curved whitish bands. Basal space narrow, dark, its outer margin curved and terminated by a white band which is diffused outwardly. Median space dark, olivaceous, terminated by a straight black line that crosses the middle of the wing obliquely from middle of inner margin to outer third of costa, followed by a white band which is diffused outwardly into olivaceous. Subterminal line black, arcuate, ending in two black streaks subapically and enclosing a little diffuse white on the upper discal venules. A broken black terminal line. Fringe dark. Hind wing fuscous, lighter toward the base, nearly whitish in the male except along the margin. Expanse, 18-24 mm.

One ♂ and 1 ♀, Hoorie, British Guiana (C. W. Beebe); 1 ♂, St. Jean, Maroni River, French Guiana, March, 1904 (W. Schaus); 1 ♀, Cayene, French Guiana, February, 1904 (W. Schaus).

Type.—No. 12662, U. S. National Museum.

Macalla pallidomedia, new species. (Fig. 42, No. 21.)

Body pale brownish. Fore wing dark brown at base and broadly terminally, the middle field diffusedly whitish. Lines thick, black, the inner obscured, the outer dentate, more slender and produced over the median nervules. Two rounded dark discal dots, longitudinally placed. Hind wing whitish, subhyaline, the apex and outer margin fuscous, more broadly so in the female than in the male. Expanse, 28 to 34 mm.

One ♀, Hoorie, British Guiana (C. W. Beebe); 1 ♂, Omai, British Guiana (W. Schaus).

Type.—No. 12663, U. S. National Museum.

The species falls in the section of the genus designated B, *a, a*[1] by Hampson (Trans. ent. soc. London, 1896, p. 466), which contains Indo-Australian species. I find a note that there was a ♀ specimen of this species in the British Museum in 1905 without a name.

Family *DALCERIDAE.*

Paracraga amianta, new species. (Fig. 42, No. 22.)

Fore wing ocher yellow, the costa at apex and outer margin narrowly white. A shining silvery area in the center of the wing, from above vein 1 to the lower part of the cell, a brown line starts from the origin of vein 2, nearly attains the costa and then returns across the discal venules to terminate at vein 1 above the expanded anal angle, inclosing an irregular rusty brown marking in the cell. A minute black dot on vein 1 at its basal third; a terminal row of similar dots at the ends of the veins, distinct only at veins 2-4 and subapically. Hind wing white with an ocherous wash, except along the margin. Expanse, 24 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12641, U. S. National Museum.

Allied to *Paracraga innocens* Schaus, but possessing a discal silvery area, while the brown line does not attain the costa.

Minacragides, new genus.

Fore wings without accessory cell; vein 11 stalked with 9, 10 absent; 6 arising above the discal vein, 7 and 8 coincident.

Minacragides arnacis, new species. (Fig. 42, No. 23.)

Entirely milky white. Expanse, 16 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12642, U. S. National Museum.

The wings are partly denuded of scales, but I can discover no traces of any markings.

Family *MEGALOPYGIDAE.*

Trosia nigripes, new species. (Fig. 42, No. 24.)

Head white, the front below and the orbits black; antennae with the shaft white-scaled, the pectinations pale straw-color. Body and wings above entirely pure white, the fore wing crossed by irregular bands of more shining scales. Wings and body white beneath, the fore legs, tibiae and tarsi of mid legs, tarsi of hind legs strongly marked with black without. Expanse 42 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12653, U. S. National Museum.

I thought at first to identify this species with *Phalæna Bombyx nivea* Stoll, which Baker placed doubtfully in Carama,

(Trans. ent. soc. London, 1887, p. 135), and which has not been satisfactorily determined; but the antennae in the figure are much too short, while the author expressly states that the feet are white.

Family *COSSIDAE.*

Hemipecten cleptes, new species. (Fig. 42, No. 25.)

Collar dark brown; thorax, with patagia, light gray; abdomen darker gray, intermixed with brown outwardly. Fore wings light gray, with transverse black strigae; area between subcostal vein and costa for the basal three-fourths and a curved band around end of cell to vein 1, darker leaden gray. A large rounded patch on outer margin from vein 3 to apex dark velvety brown, a little lighter and more leaden along the margin. This patch is edged inwardly by a line of the light ground color, within which the strigae on the wing are intermixed with ferruginous. A small dark marginal spot just above vein 2. A dark mark, like a large striga in the center of the cell. Hind wing uniformly grayish brown. Expanse, 37 mm.

One ♂, Hoorie, British Guiana (C. W. Beebe).

Type.—No. 12655, U. S. National Museum.

The specimen is almost the exact counterpart of *Cossula arpi* Schaus, at least of some male specimens before me from Omai, British Guiana, so identified. The type of *arpi* is a female from Rio Janeiro and differs from these males in having the little marginal spot joined to the large apico-marginal one. It appears, however, to be the same species. *Hemipecten cleptes,* on the other hand, differs in the structure of the antennae, while retaining the same pattern of coloration.

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Curator of Birds

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Fig. 43. Mexican Motmot on Clavallina Blossom.

RACKET FORMATION IN THE TAIL-FEATHERS OF THE MOTMOTS.

Part I.

One of the most interesting and puzzling of the myriad problems in ornithology is the apparent voluntary mutilation of plumage by birds. This phenomenon is a rare one, being confined, as far as I can ascertain, to the Momoti, a sub-order of that ill-defined group, Coraciiformes. Some twenty-four forms of Motmots are recognized, ranging from Mexico to Brazil.

It is not my intention to review in detail the well-known facts of the denudation of the tail feathers in these birds. For some time I have had under observation a living individual of *Momotus lessoni* Less. of unknown sex, and as my experiments on this bird must for the present be suspended, I have thought it worth while to record what results I have obtained.

The problem is as follows:—the central pair of tail feathers of this bird are about three inches longer than the next shorter pair, and after growth, the bird apparently plucks the web from each side of the shaft of these rectrices, for a distance of about an inch, leaving a terminal racket one and a half inches in length. If we consider this as a habit, it is an instinctive one, as proved by Cherrie* in young birds removed from the nest. These denuded their tails in perfect Motmot fashion without any chance of instruction or of imitation of the parents.

The fact that before the feathers are denuded, the webs at this point are narrower than elsewhere has been urged by Lamarckians as an instance of the inheritance of acquired characters, the argument being that Motmots have denuded their tail feathers for generation after generation, until the imperfection has in some way been transmitted to the germ, and these feathers are now congenitally imperfect. If true, this would prove almost a unique instance of this kind. Other, even more groundless, theories have been advanced, but the fact is we have

*The Auk. Vol. ix, 1892, p. 323.

known absolutely nothing of the actual cause of this phenomenon; either how it arose, why it is so persistent, or what good is accomplished.

Part II.

The Motmot is clad in browns and greens, and is a rather silent, sedentary bird. It would be thoroughly protected on its perch among green foliage were it not for a constant and violent jerking of the closed tail from side to side, through an arc of 45 to 60 degrees. This movement, accentuated by the large isolated rackets, calls instant attention to the bird as one looks in its direction. Its food in nature consists chiefly of insects and berries, although it will occasionally exhibit Shrike-like habits and turn ornithophagus.

The individual under consideration has been in my possession since September 5th, 1908, and in general has been in perfect health, moulting twice, heavily but cleanly, in September of each year. When received, the rackets were broken off, but the bare inch of terminal shaft showed that the tail feathers had been normally stripped of web. In early October, 1908, the Motmot began to preen the webs of its newly-grown rectrices and within a week the denudation was complete.

The upper limit of the stripped area appears always to be at the tips of the second longest pair of tail feathers, so the first thing I wished to discover was whether these other rectrices exercised any guiding function in aiding the bird in this remarkably symmetrical trimming.

On January 14th, 1909, I plucked out the two longest feathers and at the same time cut straight across the second and third shorter pairs of tail feathers. This took off about two and a quarter inches of the second, and one and a half inches of the third pair. These clipped feathers of course remained in the same shortened condition until the succeeding moult, while the plucked out central rectrices began growing at once.

When full grown, they were trimmed by the bird as before and careful measurements of the denuded area compared with that of the previous pair of tail feathers, showed that there was no variation. *Without the guide of the second and third rectrice tips, the trimming was as accurate as ever.*

Part III.

Early in the fall of the present year (1909) the Motmot began to moult very heavily, and became so quiet and moped so

much, with head drawn in and eyes shut, that I was alarmed. An examination showed, however, that the bird was in fair condition and would undoubtedly live through its moult. At this critical time I again plucked the long tail feathers which, by their bedraggled condition, showed the lack of care due to the moult illness. Daily I watched for the new incoming feathers, and daily the blood sheaths grew longer. Finally, when they were about four inches in length, the drying sheath began to crack and fray off, releasing the folded vane within.

When this natural unsheathing had proceeded for several days, a portion of the feather appeared disarranged. When the sheath broke from this part, the fact was made plain that the disordered appearance was due to part of the web coming away with the sheath, and the irregular breaking off of the latter made the separated barbs stand out in all directions before being lost. When the feathers grew out still more, it was seen that above the rackets the regular denuded portion of the shaft was as bare as if the Motmot had stripped it. This was an interesting result and is probably explained by the low vitality of the bird and the severe strain on its plumage-producing resources causing a lessened and insufficient nutrition in the development of these long feathers. The radical result of the physiological loss of the vane is to be interpreted by the existence of an actual weakened condition of the bases of the barbs of the normally trimmed area, which was intensified under the influence of the moulting illness in this captive bird. This increased weakness in the barbs took the form of an actual separation, simulating the dynamic denudation of the bird's beak.

Whether or not this result furnishes a proof of the inheritance of acquired characters is aside from my present thesis. I wish simply to demonstrate that in the Motmot, the condition of these tail feathers is such that transference of the denudation from a physical act on the part of the bird to a purely physiological process is not impossible, although at present abnormal.

How long it would take for this process to occur normally, in the evolution of this phenomenon, is of course impossible to say. That it would in time advance to the condition which I produced artificially is reasonable to suppose.

Compared with the normal physical results of denudation, those physiologically induced are remarkably uniform, as the following measurements in millimeters show:

	Normally Trimmed Rectrices, Removed Jan. 14, 1909.		Physiologically Denuded Rectrices, Removed Oct. 1, 1909.	
	Left.	Right.	Left.	Right.
Outer webs—				
Racket, length	52	51	50	51
Bare shaft, length........	19	23	26	26
Inner webs—				
Racket, length	54	55	54	55
Bare shaft, length........	21	22	19	22

As will be seen, the differences in the two sets of feathers are so slight as to be negligible. The only distinction is in the neatness—the physiologically denuded areas are clean-cut to the limits, while in the bird-trimmed feathers, stray barbs are left here and there near the ends of the bare area. Such a difference is interesting and to be expected.

Although it has been so stated by a number of recent writers,* I can find no authentic account of the voluntary denudation of its elongated central tail feathers by the Racket-tailed Parrot, *Prioniturus platurus,* an inhabitant of the East Indian island of Celebes. On the contrary the bird seems to have reached, or at least at present exhibits, the stage of physiological denudation—much as in my artificial condition of the Motmot.

Concerning this bird we read as follows:—**

"The specimens in the Dresden Museum prove that the webs are neither rubbed off, nor bitten off as in the case of the Motmots. . . . . Two specimens display the growing racket as found underneath the upper tail-coverts; the shaft is already webless even where it is still enclosed in the corneous husk or follicle out of which the young feather has grown and where it could of course be neither rubbed nor bitten. On removing a third younger sprouting racket by the root and taking off the epidermal husk it was found that the web is present on either side of the shaft, but some of the rami appear not to be attached at all but to run, soldered together, parallel to the shaft almost to its roots; other rami have become individually broken off or have fallen off from the shaft, and it was easy to see that, as the feather grew longer, all would have fallen from the shaft. In a growing racket with the shaft 35 mm., cut out of the tail of an adult male bird it was not possible to detect any signs with cer-

*For example, "Through Southern Mexico," Gadow, p. 483.

**"Birds of Celebes," Meyer and Wiglesworth, Vol. i, p. 74.

Fig. 44. Tail-feathers of Mexican Motmots, Showing the Beginning and Completion of Racket Formation.

Fig. 45. Tail-feather of Lesson Motmot, Showing Physiological Denudation.

tainty . . . . another shaft was found to be bare down to its point of attachment by the side of the oil-gland; near the base alone some corneous matter of uncertain determination, but perhaps feather-material, was adhering to it.

"These investigations tend to prove that no web at all is produced with long-shafted rackets, but rackets of a lower stage of development have imperfect or unattached webs which fall off before the racket is fully exposed."

Part IV.

Now as to the relation in the Motmot, between the permanently feathered and the ontogenetically defeathered areas of the two rectrices. The fact of the narrowing of the webs has already been mentioned. In a specimen of *Momotus mexicanus* Swains, in my collection (No. 819) the narrowing of the vane begins considerably above the area of subsequent denudation. At its narrowest part the constricted area, compared with the width of the normal vane, is as 3 : 4.

Microscopic examination yields certain results of value in connection with my experiments. The full-grown right central rectrice of one of my specimens, *Momotus mexicanus* (No. 819) is untrimmed except for fourteen barbs on the inner web, the absence of these leaving the shaft bare for a distance of 11 millimeters. Now the racket in this species, as shown by several other trimmed specimens, is about an inch and a quarter in length and holding this untrimmed feather up against the light one can perceive at once what will be the ultimate area of denudation. Elsewhere the vane is dense and compact close up to the shaft, but in this area the basal portion of the barbs is bare, allowing the light to pass through, distinctly near the center of ultimate denudation and graduating down to the normal condition of the feather at the limits of the area.

The rectrices of *Momotus lessoni* being larger and coarser in every way, show this condition even more distinctly, especially where a single stray barb has escaped the beak-trimming process. Even in a fully trimmed feather, a certain amount of imperfection of the basal portions of the barbs is visible for some distance at each end, showing that the actual area of weakened feather structure is greater than the area trimmed by the bird. *The result of the bird's preening is apparently controlled by the weakness and ease of fracture of the barbs rather than by proximity of other feathers or of visual estimate of the size of the racket.*

This has been hinted at by Dr. Stejneger* but unfortunately for his illustration, he has used a feather exhibiting an ordinary fault-bar, caused, as we know, by some sudden and local disturbance in nutrition, either of the bird as a whole or of a particular feather follicle. Similar faults may result from so slight a cause as the difference in blood pressure during the sleeping and waking hours. This results in a transverse faulting across the entire vane—affecting the tips of the proximal barbs and the centers or bases of those more distal ones which are in process of development at the period in question.

The weakness of the vane of the Motmot's tail is far more fundamental, in reality an organic inheritance; the faults or degeneration affecting only the bases of the barbs within a definite limited area—and the faulting thus being longitudinal. Of considerable interest is Stejneger's illustration of a specimen in the collection of the United States National Museum, where a slight denudation—symmetrical in the two feathers—exists on a pair of rectrices which have only just escaped from the enveloping sheath. This would seem to indicate that physiological denudation has already begun in nature and that the bird's part is becoming a subordinate one.

Under a magnification of twenty-five diameters, the distinction between the normal and the weakened portions of the vane is seen to consist in the dwarfing or absence of the barbules, and of a very slightly reduced diameter of the basal part of the barb itself. The degeneration of the barbules has been greater on the inner side next to the shaft, where in many cases the barbules have totally disappeared.

Under the lens, the clean mechanical work of the purely physiological action as compared with the clumsier trimming of the rough beak is plainly visible; the shaft being cleaner and the barbule stumps more regular in the former case.

The physiologically denuded tail feathers reached their full growth within a period of six weeks, and on October 1st, 1909, were in their turn plucked out for examination and reference. The bird had of course by this time completely finished its moult and was in perfect condition.

Part V.

The final stage of this experiment was the observation of the growing tail feathers, succeeding those plucked out October

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*Riverside Natural History, Vol. iv, p. 399.

1st. They were slow in starting, but became visible beyond the upper tail-coverts in three weeks and on November 8th had reached a total length of four and one half inches. A compact, unbroken blood sheath surrounded the shaft to within three inches of the tip. Several days previous to this the barbs had been observed to be in disorder as they emerged from the sheath and on one occasion the bird was seen to preen the right feather, pick off a bit of broken sheath and with it several barbs!

On November 8th the denudation had proceeded to a considerable extent and the left feather presented the appearance seen in Fig. 45. The right side of the shaft is comparatively clean while the left side is as yet only partially denuded.

The blood sheath on the right feather was one and three-quarter inches in length and encroached on the area of normal denudation for the last quarter inch. With a pair of pliers I gently pried up the dry end of the sheath and with it came four barbs, leaving two, still affixed to the shaft, so firmly attached that a gentle rubbing did not detach them.

There is not the slightest chance that the bird could have removed this bit of sheath with greater care than did I, so we must conclude that the unusual physiological weakness of the barbs which was so pronounced in the previous pair of feathers that they were perfectly denuded on being freed of the sheath, was continued, but in a less degree in the present set of rectrices. In the succeeding set, perhaps a normal balance will be attained.*

The objection may be raised that this is all a result of abnormal ecological conditions surrounding a captive bird, but it must be remembered that in the several sets of feathers grown before I began my experiments, the feathers attained their full length before being denuded.

Mr. F. M. Chapman has called my attention to two interesting specimens of *Eumomota superciliaris* recently received by the American Museum from Nicaragua. In this species the denudation of the tail-feathers reaches an extreme, the central pair of rectrices extending four and a quarter inches beyond the others, with almost three inches of bare shaft.

In the two specimens mentioned, the central tail-feathers are only partly grown, with only a portion of the denuded area out of the sheath. The web on this portion shows an extreme degeneration, comparable to the normal condition in the tail of

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*December 4, 1909. This is confirmed at the present date, when the tail feathers have emerged with unbroken vanes from their sheaths, and the bird thus proved to be in normal condition again.

the parrot *Prioniturus.* The barbs are scanty, but probably are all present when the shaft first emerges from the blood sheath. Each barb breaks off at the proximal end of its line of green pigment. The most noticeable character is the great degeneration in length of these barbs. At the base of the racket the barbs measure one and a quarter inches in length, while barely a half inch farther up the shaft, the barbs are reduced to one-quarter of an inch in length. The dropping off of the barbs is almost contemporaneous with their breaking from the sheath, the shaft being bare long before it has reached its full growth.

Judging from the condition of the rectrices in these two moulting individuals of *Eumomota superciliaris,* the evolution of tail denudation is more advanced in this species than in any of the others I have examined.

A curious asymmetrical condition was observed in a specimen of *Momotus subrufescens* in the collection of the American Museum. The character is apparently individual, as it is not present in other specimens. On holding one of the rectrices, which is intact, up to the light, the longitudinal series of holes which indicate degeneration is observable only along the inner life of the shaft. In the other rectrice the inevitable result of this condition is demonstrated in the asymmetrical denudation, the outer web being entirely absent while the inner web is perfect, and shows no hint of losing even a single barb. This is additional proof that the denudation is wholly dependent on the congenital weakening of the barbs.

Part VI.

My conclusions as to the problem of rectrice denudation in the Motmot are as follows: For some reason, totally unknown to us at present, a certain definite portion of the central rectrices of these birds exhibits congenitally a decided degeneration of the barbs and barbules.

These weakened barbs are usually strong enough to resist the ordinary wear and tear of the feather during its growth. The natural oil or moisture of the feather may not totally evaporate from this terminal portion until growth at the base ceases, although there can be no direct communication between the two points. It is a minor consideration whether the final increase of weakness is due to thorough drying and consequent brittleness or to some other physiological cause.

The Motmot, in the course of the preening to which it subjects all of its rectrices, breaks off the barbs in the area most

Fig. 46. Showing Congenital Weakness of the Barbs.

Fig. 47. Normal Portion of the Feather.

Photo-micrographs of a Tail-feather of the Lesson Motmot, magnified 25 diameters.

affected by this degeneration, and thus brings about the remarkable, symmetrically formed rackets. If, as seems inevitable, we must take this view of the phenomenon, the fact of the narrowing of the vane at the later denuded portion, requires no "inheritance of acquired character" explanation, but takes its place as one of several features of degeneration—the original cause of which is as yet unknown to us.

I come to these conclusions rather unwillingly, as ever since my intimacy with Motmots in the field in Mexico,* I have always held these birds in the highest regard, especially for this inexplicable feat of self-decoration.

My conclusions have been forced by the following facts:

1. If considered as a voluntary congenital habit, the fact that it is absolutely unique and inexplicable.
2. The presence of the phenomenon in both sexes.
3. The absence of individuality in trimming, resulting in
4. Physiological accuracy in all instances.
5. Lack of special attention paid, in preening, to the racket feathers.
6. The extreme degeneration of the area, and consequent
7. Fragility of the barbs.
8. The present narrow limits between actual physiological denudation in the sheath, and ultimate preening-denudation.

Further work with a number of living birds, Motmots and Parrots, will do much to clear the field of negative factors, leaving the bare facts of physiology and habit to be correlated with the ecological conditions of life, in this and related problems.

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*"Two Bird-lovers in Mexico," pp. 198-204.

THREE CASES OF A SUPERNUMERARY TOE

IN THE BROAD-WINGED HAWK, BUTEO PLATYPTERUS (VIEILL.).

I have thought it worth while to put on record three separate instances of an extra toe being present on the leg of a Broad-winged Hawk, *Buteo platypterus.* While these may

Fig. 48. Leg of Broad-winged Hawk from Illinois.

prove to have no direct evolutionary significance as reversions or as examples of polydactylism, still the occurrence of the phenomenon in three individuals of the same species from widely different localities appears to be more than a coincidence.

Fig. 49. Leg of Broad-winged Hawk from Brooklyn.

Fig. 50. Leg of Broad-Winged Hawk from Ontario.

Part I.

In "The Auk" for October, 1887, Vol. iv, No. 4, pages 331-333, is a short article entitled "Ornithological Curiosities,—A Hawk with Nine Toes and a Bobolink with Spurs on its Wings," by Henry K. Coale. An excellent wood cut is given of the foot and leg of the hawk, together with the following information:

"No. 5924 (Mus. H. K. C.), *Buteo latissimus* (Wils.), Broad-winged Hawk. Shot in small woods half-mile S. E. of Grand Crossing, Ill., Sept. 6, 1884. Length, 14.75; extent, 32.50. Legs and feet yellow. Bill black, cere greenish. Iris yellowish buff. Stomach contained crayfish.

"The extra toe . . . . grew out from the thigh, just above the ankle joint. It was not connected with the bone, but could be moved in any direction, seeming to grow from the muscles of the thigh. The upper bone slightly curved; one movable joint, a straight bone, and a perfect, movable claw. Color yellow, claw black, like the normal toes.

"Professor Ridgway writes (1884) that the only bird in the National Museum collection having abnormal toes is a Gull. It is evidently a thing of rare occurrence."

The extra toe is on the right leg and springs apparently from the same posterior plane as the hind toe. The length of the entire toe and claw is 46 mm., greater apparently than the middle toe and claw. The scalation is normal. (Fig. 48.)

Part II.

In the Childrens' Museum, Brooklyn, is a mounted female Broad-winged Hawk which possesses an extra toe on the left leg, growing from the posterior aspect of the tarsus, in the same plane as the hind toe, but elevated 6 mm. above that digit. It is thus about three-quarters way down the tarsus. The length of this abnormal toe and claw is 22 mm., making it but little shorter than the hind toe, while the claw itself is fully as large as that of the hind toe. It apparently possesses two phalanges and the scalation is normal, corresponding with that of the hind toe. If it were muscled, its position would admit of its functioning in seizing and holding prey.

The bird was collected in Prospect Park, Brooklyn, by Mr. Zartmann, and my attention was called to it by Dr. F. A. Lucas. (Fig. 49.)

Part III.

Two young Broad-winged Hawks were taken from a nest in Chemong Park, Peterboro County, Ontario, Canada, by Mr. David Bull about August 12th, 1907. They were brought to New York and sent to me at the Zoological Park on September 11th.

Both parents had been shot and were normal as regards the number of toes, and one of the young birds showed nothing out of the usual. In the second young hawk an extra toe appears on the left leg. It arises from the posterior surface of the tarsus about 14 mm. above the hind toe. Its insertion however is on the inner angle of the large scutes. It is extremely degenerate, the single phalanx forming a mere scaly nodule only 4 mm. in length. The claw is long and thin, measuring full 11 mm. in length and is curved outward across the whole width of the tarsus. (Fig. 50.)

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THE UNDESCRIBED JUVENAL PLUMAGE OF THE YUCATAN JAY.

By

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and

Lee S. Crandall, *Assistant Curator.*

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THE UNDESCRIBED JUVENAL PLUMAGE OF THE YUCATAN JAY.

Cissilopha yucatanica (Dubois).

I.

On September 3, 1911, three jays in immature plumage were received from Yucatan. The plumage was a hitherto undescribed one, and a drawing was made of one of the birds on September 8. The subsequent postjuvenal moult transformed the birds into undoubted *Cissilopha yucatanica.* This change is described in detail in Part II of the present paper.

Both Sharpe (1) and Salvin and Godman (2) describe the female of this jay as differing from the male in having the beak yellow instead of black and the outer rectrices tipped with white. Our collector who brought north the young birds, reflecting the opinion of the natives in Yucatan, asserts that the white rectrice tips alone characterize the female. Ridgway (4) describes the adult sexes as alike, and considers the yellow beak and white-tipped rectrices as "immature" characters. This he evidently bases on Chapman (3) whose notes on this species are obtained at first hand in the field. Chapman writes as follows:

"Current descriptions of this bird, including that in the 'Biologia,' ascribe the differences shown by certain individuals in the color of the bill and tail to sex, the male being stated to have a black bill and tail, while the female is said to have the bill yellow and the tail tipped with white. My series of twelve specimens shows that this variation is not sexual, but is evidently due to age. Thus I have males and females with black bills and tails, and also examples of both sexes in which the bill is yellow and the tail tipped with white. The series also contains intermediates between the two extremes.

1—1877. Sharpe, Cat. Birds Brit. Mus., III, 133.
2—1887. Salvin and Godman, Biol. Cent.-Amer., Aves, I, 498, pl. 35.
3—1896. Chapman, Bull. Amer. Mus. Nat. His., VIII, 282.
4—1904. Ridgway, Bull. U. S. Nat. Mus., No., 50, Part III, 315.

"How long a time is required for the acquisition of the adult plumage remains to be determined. Apparently at least two years, for each group of jays had several yellow-billed individuals, about one in every four birds giving evidence of immaturity."

The chief points of interest may be thus summed up:

1. The juvenal plumage of *Cissilopha yucatanica* is characterized chiefly by the entire head, neck and under parts being white; bill and eye-ring orange yellow; iris pale hazel brown; all but the central rectrices more or less tipped with white. This white plumage is retained from the time of leaving the nest, about July 15th, until October.

2. The first winter plumage is acquired exactly as in our northern *Cyanocitta cristata* by a partial postjuvenal moult (Dwight [5]), reaching its height in October. The head, neck and under parts become black; the iris darkens to a cold slaty gray; the primaries and rectrices are not moulted, but if the latter are accidentally pulled out, they are replaced with feathers showing no trace of white.

3. The advance toward an adult plumage in this species is marked chiefly by an increase in dark pigment; sudden and complete in the body plumage of head, neck and under parts in the fall moult, and in the lateral rectrices in the first moult of the following year; more gradual in the color of the iris; and still more gradual in the color of the mandibles and eye-ring.

II.

JUVENAL PLUMAGE OF THREE INDIVIDUALS.

Individual A.—(Fig. 51.)

Seven Weeks Old (September 8, 1911).

Head, neck, breast, belly and under tail-coverts pale creamy white, faintly tinged on the crown with blue, all of the white feathers with sooty black bases; above, pale blue, with a few new feathers of brighter blue; wing-coverts like the back; remiges

5—1900. Dwight, Ann. N. Y. Acad. Sci., XIII, 152.

Fig. 51. Yucatan Jay in Juvenal Plumage

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sooty black on inner web and rachis, (rachis white below), outer web bright blue like new back feathers. The blue on the tip of the inner web gradually increases, from the outer feathers inward, so that the inner secondary is uniform blue, with the exception of the proximal portion of inner web. Under wing-coverts sooty black, with faint lighter bars; tail bright blue above, black below; rachis black above and below; thighs brownish black, tinged with blue at the tarsal joint. Legs and feet pale yellow; bill orange yellow. Iris dark hazel brown. A small patch of black feathers is appearing at either side of the breast and scattered ones throughout the rest of the under parts, but none on the head. In both this and the other individuals the rectrices are so broken that it is impossible to state the amount and place of occurrence of the white. Bill 32 mm., tarsus 46 mm.

Sixteen Weeks Old (November 18, 1911).

Feathers of the head, neck and upper breast deep black, a few white feathers, interposed with black ones, remain above and below the eyes and on the lores and chin. The lower breast and abdomen are slightly tinged with blue, which becomes more distinct on the under tail-covers. The back and scapulars are uniform bright blue. The lesser coverts, carpal edge and inner median coverts have been renewed and are like the back, but the outer median coverts and all the greater coverts have not as yet been moulted. Wing and unplucked tail feathers have not been renewed, nor have the under wing-coverts and the feathers of the thighs. The eye-lid is bright yellow, the bill and legs somewhat paler. The iris is dark slaty gray. All of the feathers, except rectrices, remiges and upper wing-coverts, are loose in texture, the barbs few, long and disconnected. Bill 33 mm., tarsus 46.5 mm.

Individual B.

Seven Weeks Old.

Similar to A, except that the sooty bases are present on only a few isolated feathers; a distinct blue tinge on the crown; thighs wholly bluish black; pectoral tracts of incoming black

feathers further advanced; crown, nape and sides of the neck thickly sprinkled with black blood-feathers. Bill orange yellow. Bill 35 mm., tarsus 47 mm.

This specimen was skinned and preserved in its juvenal plumage.

Individual C.

Seven Weeks Old.

Shows sooty feather-bases on only the anterior part of crown, where they are very pronounced. Black feathers on breast are more scattered and more advanced than in A and B; thighs bluish black. One or two dark feathers appear on the crown. Bill clear orange yellow. Bill 31 mm., tarsus 45 mm.

Sixteen Weeks Old.

Similar to A, but breast and abdomen uniform black, only the under tail coverts tinged with blue. No white feathers remain. The thighs are deep black, very slightly tinged with blue near the tarsal joint; these feathers have evidently been renewed. The under wing-coverts have been moulted and are deep black, slightly tinged with blue. Back, scapulars, carpal edge, and wing-coverts have been moulted, but not the remiges or rectrices. Bill and legs clear yellow, iris dark slaty gray. Bill 33mm., tarsus 47 mm.

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SCIENTIFIC RESULTS OF THE EXPEDITION TO THE GULF OF CALIFORNIA, IN CHARGE OF C. H. TOWNSEND, BY THE U. S. FISHERIES STEAMSHIP "ALBATROSS" IN 1911, COMMANDER G. H. BURRAGE, U. S. N., COMMANDING.

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II

THE NORTHERN ELEPHANT SEAL

Macrorhinus angustirostris, Gill

BY

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Director of the New York Aquarium.

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FIG. 52. VIEW OF NORTH END OF ELEPHANT SEAL ROOKERY, GUADALUPE ISLAND.
Males, females, two-year-olds and yearlings. The males with heads erected are in fighting attitude, with proboscis retracted and mouth wide open. U. S. S. *Albatross* in distance.

THE NORTHERN ELEPHANT SEAL.

Macrorhinus angustirostris, Gill.

BY CHARLES HASKINS TOWNSEND,
Director of the New York Aquarium.

Illustrated with Photographs by the Writer.

The elephant seal is the largest of all seals and owes its name to its great size and to the remarkable trunk or snout developed in the adult male.

The northern elephant seal has long been on the verge of extinction and is now found only on Guadalupe, an uninhabited island lying in the Pacific Ocean 140 miles off the northern part of the peninsula of Lower California.

It formerly had a range extending from Cape San Lazaro near Magdalena Bay on the Peninsula, northward to Point Reyes near San Francisco, California, a distance of nearly a thousand miles, and has never been definitely recorded from any other region of the North Pacific Ocean. It was abundant at several points along the coast and especially so on all of the islands off the west coast of Lower California.*

Being valuable for its oil it was killed in large numbers by vessels primarily engaged in the pursuit of the gray whale which was also abundant in the same region. There is a record showing that the elephant seal was being killed for commercial purposes at Santa Barbara Island, California, as late as 1852. During the late fifties, apparently, its numbers in Lower California became reduced to mere scattered groups.

Captain C. M. Scammon, who has long been the principal authority on the northern elephant seal, writing in 1869,‡ reported that it was then "nearly if not quite extinct." Since the publication in 1874 of his work on the Marine Mammals of the

*The habitat of the southern elephant seal originally extended throughout the Antarctic islands, including Kerguelen, Heards, St. Paul, Tristan-da-Cunha, Falklands, Tierra del Fuego, South Georgia, South Shetlands, Juan Fernandez and islands south of New Zealand. It has disappeared from some of these places and is now found chiefly at Kerguelen Island.

‡Proceedings Academy Natural Sciences, Philadelphia, April, 1869, pp. 61-63.

Northwestern Coast, there has been little information available respecting the species.

In 1884 and again in 1892, I obtained information from seal hunters in California that 419 elephant seals had been taken by them at various times from 1880 to 1884 at San Cristobal Bay and Guadalupe Island, Lower California. According to my informants, some of whom had long engaged in sealing in a desultory way, the elephant seal became scarce about 1865, and only a few stragglers had been found until the discovery of a small herd at San Cristobal Bay in 1880. This bay occupies a midway position on the Peninsula and is uninhabited, there being no fresh water along the coast within fifty miles. As the beaches are .narrow, elephant seals found lodgment chiefly in the dry gullies opening into them.

I visited this locality in October and December, 1884, in the schooner *Laura* of San Francisco in search of specimens of the elephant seal for the United States National Museum* The beach frequented by the seals was kept under observation from October 20 until December 31, but we obtained only sixteen animals, the skins and skeletons of which were secured for the National Museum. I visited a number of other localities on the same voyage, but the species was not observed elsewhere, although we searched both the coast and the islands as far south as Magdalena Bay. We examined the shores of Guadalupe Island in October, but on account of unfavorable weather, overlooked the locality at present occupied by the elephant seal on the northwest side of the island. It may have existed there at that time.

In 1892, I again visited Guadalupe Island in the schooner *Santa Barbara,* under the auspices of the Department of State, with a view to identifying the species of fur seal known to exist there, the information being desired for the use of the Fur Seal Arbitration then convened at Paris.† Although the entire coast line of the island was carefully examined during our search for the fur seal, we found no trace of the elephant seal until we

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*An Account of Recent Captures of the California Sea Elephant and Statistics Relating to the Present Abundance of the Species. By Charles H. Townsend. Proc. U. S. National Museum, 1885, pp. 90-93.

†Notes on the Fur Seals of Guadalupe, The Galapagos and Lobos Islands. By Charles H. Townsend, Report on Fur Seal Investigations 1896-97, part III, pp. 265-69, Treas. Dept., Doc. No. 2717, Div. Special Agents.

reached the so-called Elephant Beach under the cliffs on the northwest side. According to Captain Hunt of the schooner *Santa Barbara,* eighty elephant seals were found on this beach in 1883. Here we found eight elephant seals, seven of which were killed, but the weather conditions becoming suddenly unfavorable and the landing dangerous, we were compelled to abandon four of these. At that time, May 23, the larger animals were shedding their hair.

The fur seal obtained at this island proved to be a new species of the Antarctic genus and was described as *Arctocephalus townsendi* by Merriam.

Captain J. R. Mullett of Monterey, California, is said to have obtained a few specimens of the elephant seal in 1904, presumably at Guadalupe. In 1907 Mr. Charles Harris visited Guadalupe Island in the interest of the Hon. Walter Rothschild, remaining from June 2 to 13. He found about forty elephant seals and obtained fourteen specimens, four of which were lost in the surf.*

For many years no reports have been received from San Cristobal Bay and other points in Lower California formerly inhabited by the elephant seal, and there has been no further account of the small herd found at Guadalupe Island in 1907. As Lower California is sometimes visited by parties in small vessels in search of sea-lions which are killed for their hides and oil, naturalists had little hope of its continued existence, and the recent discovery of a herd of considerable size was a matter of surprise and great zoological interest.

Rediscovery in 1911.

During the winter of 1911 while in charge of the deep sea investigations of the United States Steamship *Albatross* in the Lower California region, I called at Guadalupe Island and was fortunate enough to secure the specimens, photographs and data upon which the present paper is based.

We reached Guadalupe on March second, and immediately landed the members of the scientific staff on the east side for a day's collecting and proceeded at once with the ship to the north-

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******Mirounga angustirostris* **(Gill), by the Hon. Walter Rothschild, Ph. D., Novitates Zoologicae, vol. XV, 1908, p. 393. Mr. Harris also published an account of this trip to Guadalupe Island in the Pacific Monthly for April, 1909, entitled A Cruise After Sea Elephants.**

west side in the hope of finding a few survivors of the elephant seal.* After a forenoon's search we located a herd of about 125 of these animals on Elephant Beach. I killed one large male and one large female which we skinned and took to the ship. Returning with larger boats and some nets, six yearlings were captured alive and sent on board. While the *Albatross* went to the east side to pick up the scientific staff, I devoted the afternoon to making observations and taking photographs, the ship not returning until nightfall. There is deep water all about the Island, but after much cautious sounding Commander Burrage found an anchorage in fifteen fathoms of water about a mile off shore. The following day being too stormy to make landings, the time was spent in the preparation of our specimens. On the morning of the fourth we succeeded after some difficulty in effecting a landing when I killed two more of the large males the skinning and skeletonizing of which occupied us for several hours.†

The sea becoming rough, we were compelled to leave the beach in the afternoon and the embarking of our heavy specimens was both difficult and dangerous.

Elephant Beach is located under high and impassable cliffs and is flanked by cliffs which extend into the sea, making the top of the island altogether inaccessible from this point. Its northern end is well marked by heavy rock slides. The beach is accessible from the sea only, and is usually further protected by a heavy surf. It is not more than three or four hundred yards in length by thirty in width, the greater part of it is sandy, the inner margin being lined with talus from the cliffs.

The seals had little fear of man, and the few animals which left the beach would probably not have done so had they not been disturbed by sailors walking among them. While the large specimens were being skinned and skeletonized, some of the animals slept undisturbed within thirty feet of where the men were working. I succeeded in obtaining about fifty good photographs showing the general character of the rookery and the attitudes of the animals. The herd consisted chiefly of large males and im-

*Members of scientific staff: Dr. J. N. Rose, Dr. Paul Bartsch, U. S. National Museum. W. L. Schmitt, L. M. Tongue, U. S. Bureau of Fisheries. Preparators: H. E. Anthony, J. C. Bell, American Museum of Natural History.

†These skins are now being mounted and will constitute an important group in the American Museum of Natural History.

mature animals of various sizes. There were probably not more than fifteen adult females present and only six of these were accompanied by newly born young. The indications were, therefore, that the breeding season was just commencing and that other adult females might arrive later. We did not observe any male with more than one female, and the family groups were distributed all along the rookery.

Size.

The three males which we killed were the largest in sight and were found to average just sixteen feet in length, with an average girth of eleven feet. The largest specimen of the northern elephant seal recorded as actually measured was "twenty-two feet long from tip to tip and yielded 210 gallons of oil."* The adult female we killed was nearly eleven feet long. Some of the females with young pups appeared to be slightly longer, but we did not attempt to measure them. There were numerous immature males about the size of the adult female and many animals of intermediate sizes between these and the newly born pups. Animals of the yearling size were distinctly more numerous than those of any other size. The newly born pups were quite distinguishable in color from the yearlings, being dusky black. They were about a week old. The color of the adults is yellowish

*Scammon. Overland Monthly, February, 1870. In this article the writer refers to individuals that attained "the enormous dimensions of twelve feet in circumference and more than twenty-four feet in length. Lydekker, in discussing the Antarctic species says, "Probably twenty-five feet would not be an undue estimate for the length of an adult male, and it is far from improbable that close upon thirty feet may have been reached in some cases." Morrell says, "I have seen the male (Antarctic) sea elephant more than twenty-five feet in length, and measuring sixteen feet around the body."

The elephant seal is much larger than the walrus, which does not exceed thirteen feet in length or fourteen feet in girth.

Captain B. D. Cleveland of New Bedford, Massachusetts, who has during the past dozen years made several voyages to Kerguelen Island after elephant seals, says in a recent article in Hampton's Magazine that the largest males measure sixteen feet in length, thirteen feet in girth and may yield as much as 245 gallons of oil. He found the blubber to be seven inches thick on the fattest animals at the commencement of the season, six or eight weeks later it was not more than two inches thick, the seals having fasted in the meantime. Captain Cleveland says he secured from 2,600 to 3,000 barrels of oil on a voyage, that the animals are killed by shooting and that the skin has no commercial value. Sealing begins in November and ends in May before the harbor freezes over. With a crew of thirty-five men, 120 elephant seals were killed and stripped in one day. The oil is worth from forty-seven to fifty cents a gallon.

brown, the younger animals being grayish brown. The largest male elephant seal obtained by Harris in 1907 was sixteen feet, eight inches in length and had a girth of eleven feet, eight inches. The proboscis was eighteen inches long, measured from its tip to the eye. The largest female obtained was eleven feet, five inches long, with a girth of six feet, five inches.

The skin of the adult male is exceedingly heavy, being nearly an inch thick about the fore part of the neck. Our knives dulled so rapidly in skinning that it was found necessary to have a grindstone sent ashore and keep two men busy at the task of sharpening. The carcasses were so heavy that it required all the strength of half a dozen men to turn them over with the aid of a rope and hand-holes cut in the skins. We found the blubber to be about four inches thick in some places.

Behavior of Males.

Unless actually teased by members of our party, the old animals did not attempt to leave the beach, and many of them did not raise their heads from the sand until closely approached, although wide awake. When driven from a comfortable resting-place they would soon settle down, and after throwing sand on their backs with the front flippers become quiet again. Both young and old have the habit of covering themselves with sand when settling down to rest. The females, although but little molested, appeared to be even more passive than the males.

Some of the large males after being driven into the sea, soon returned. While in the water they remained near the surf, disregarding the boats which passed near them, the head being usually held well above water with the proboscis partially retracted. When making a landing the large male does so very slowly with frequent pauses, from time to time raising and spreading the hind flippers to get the benefit of each low wave that helps him through the shallows. When finally clear of the water and dependent upon his own efforts in getting his ponderous bulk to a dry place well up the sloping beach, progress becomes very slow, but the elephant seal is able to crawl long distances. While at San Cristobal Bay in 1884, the sealers showed me places three or four hundred yards up the ravines where they had formerly killed them.

Most of the attitudes here described are well shown in the accompanying photographs, but it must be confessed that we could not have secured all of our pictures without getting the animals thoroughly aroused. In some cases I focused my camera on the head of an elephant seal at a distance of eight or ten feet and then had a sailor kick the animal violently in the ribs, one of them became thoroughly angered only after a sailor had jumped upon his back. When moving of its own accord the elephant seal arches the body in a way suggestive of the motion of the inch-worm, drawing the hind quarters well forward with the belly lifted from the ground, and then shifting the forequarters with the front flippers braced outward.

Fighting.

The large males that accompanied the nursing females were frequently engaged in fights with unattached males. There had evidently been considerable fighting as their necks were more or less raw and in some cases had festering sores. In comparison with them the necks of the younger males were smooth and without tooth-marks. In fighting, the large males crawl slowly and laboriously within striking distance, and then rearing on the front flippers and drawing the heavy pendant proboscis into wrinkled folds well up on top of the snout, strike at each other's necks with their large canines. The fighting was accompanied with more or less noise and snorting, but we heard none of the extremely loud bellowing described by writers as characteristic of the Antarctic species of elephant seal.

The skin of the under surface of the neck and fore part of the breast is greatly thickened, it is practically hairless and years of fighting has given it an exceedingly rough and calloused surface. This *shield,* as it may be called, is the part of the animal most exposed to attack when fighting, it extends from the throat just below the base of the jaws, down to the level of the flippers and rather more than half way back on each side of the neck and breast. Although ugly wounds are inflicted by the large canines, the heavy skin in no case seemed to be broken through. While the animal takes good care of its head and proboscis, the calloused breast shield is freely exposed to the enemy.

The fighting is not of the desperate sort indulged in by the fur seal, and the contestants soon separate; there seems to be no actual seizing and holding of the skin and after each sharp blow the head is quickly withdrawn and held aloft. When the head of the male is elevated, the skin at the top of the neck and shoulders is thrown into a series of eight or ten heavy folds which extend downward and forward. These folds do not show when the animal is at rest with the head stretched forward on the sand. The fore flippers are large and thick and have heavy claws, the posterior three claws being well separated.

Proboscis.

The proboscis is broad and fleshy to the tip where the nostrils are placed, the nasal openings being wide apart and directed somewhat downward and outward. The length of the proboscis forward from the canines is about equal to the distance between the canine and eye. It is exceedingly thick and heavy and its width is about equal to the space between the eyes. In one of our specimens, not the largest, it was about nine inches long, but the proboscis of the dead animal can be stretched out somewhat longer.* When the animal is crawling the proboscis is relaxed and pendant; when sleeping, it rests upon the sand in a shapeless mass. When persistently annoyed the old male slowly raises his head, and retracting the proboscis opens the mouth very wide. He does not bellow loudly but there is much blowing out of the breath through the nostrils with a gurgling sound, the whole proboscis vibrating heavily with the effort.

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*Cleveland says of the southern species that it has "a trunk fifteen inches long;" meaning doubtless its full length back to a point opposite the angle of the mouth.

In our largest skull—twenty-three and three-quarter inches long—the distance between the canines and the orbit is nine and one-half inches. In the dried and still unmounted skins of our three males, the distance between the tip of the proboscis and the eye averaged twenty-three inches, but the skins may have been somewhat stretched. In the largest of these skins the distance from the first row of whiskers to the tip of the snout, is fourteen inches. In the largest male obtained by Harris, the distance from tip of proboscis to eye was eighteen inches, making the length of the proboscis forward from the canines about nine inches. Scammon (Proc. Acad. Nat. Sci., Phila., 1869, pp. 61-63) says, "the proboscis of the northern species in a large male extends from opposite the angle of the mouth forward about fifteen inches." The United States National Museum has a skull obtained at San Cristobal Bay in 1884 by C. H. Townsend which is twenty-four inches in extreme length.

Sometimes when the head is turned up, the proboscis relaxes until it hangs into the open mouth. The animal may continue to turn its head over backwards until the half-relaxed proboscis actually overhangs to the rear. We did not at any time see the trunk thrown into a rounded or tubular form. In fighting it is closely retracted and the seal is apparently successful in keeping it out of harm's way, as many of the animals with badly damaged necks, had trunks showing no injury whatever.

When the proboscis is fully retracted it exhibits three bulging transverse folds on top separated by deep grooves. The upper groove remains distinguishable when the proboscis is relaxed, while above it the upper fold remains as a fleshy hump. We did not observe any actual inflation of the trunk, which, as examined during the skinning operations, is fibrous and fleshy throughout. There was no special expansion of the nasal passages observable, and while the photographs appear to indicate an inflation, such is not the case; the heavy folds of the retracted proboscis must be produced by purely muscular action. It cannot be capable of inflation in the sense that the trunk of the male hooded-seal (*Cystophora*) is inflated. The massing of the heavy fleshy appendage into compact folds on top of the head, is really the opposite of inflation. There is little indication of the proboscis in the half-grown male; it probably does not develop until sexual maturity is reached. Under excitement both female and young extend the nose into a sharply pointed tip.

A careful examination of all available published photographs of the Antarctic species has failed to show in any case, a proboscis as long as those shown in our photographs of the northern species.

Food.

I have not found anything in the stomach of the elephant seal that would serve to indicate the nature of its food; in fact we never found anything but a handful of sand. Our captive elephant seals refused to eat fresh fish during the two days voyage to San Diego and took no food for more than a week after their journey overland. In the New York Aquarium they have subsisted entirely on fresh fish cut into moderate sized pieces, but

greatly preferred it alive. Live crabs and bits of seaweed placed in their pool always remained untouched.

They doubtless feed on live squid like the fur seal, but refused the dead squid we took pains to procure for them. Peron found cuttlefish beaks and *Fucus* in the Antarctic elephant seal's stomach. Lambert says, "their food is chiefly kelp, but I have found squid in their stomach." Harris found "tiny sardines not more than two inches long" in the stomachs of some of the elephant seals taken at Guadalupe Island; such fishes being abundant at the mouths of the sea caves near by. Cleveland describes the food of the southern species as consisting of "cuttlefish and mollusks."

The heavy claws of the fore flippers may be useful to the animal in procuring mollusks from sandy bottom.

Young.

The yearling elephant seal is somewhat heavier and longer than the nursing pup, but is proportionately more slim, brownish gray in color and has longer whiskers. The nursing pup is *black* and its length is about four feet. It is so remarkably fat as to be practically unable to move, while the yearling is quite active. None of the six yearlings brought to the New York Aquarium exceeded five feet in length. Their weights varied from 167 pounds to 301 pounds, males being heavier than females.

The nursing female was usually accompanied by a yearling, as well as a young pup. Doubtless the presence of the yearling with the adult female accounts for the conflicting statements of sealers about the breeding season. Judging from the conditions that we observed at Guadalupe Island, the breeding season begins just before the first of March. The period of gestation must be nearly twelve months,* as the females with black pups about a week old, were already mating. I am convinced that the young animals I described in 1884 as pups were really yearlings. I never saw the *black* pup until 1911, and there are none in museums, at least in America.

*Twelve months is known to be the period of gestation in the fur seal. Captain Cleveland makes the statement that the female of the southern elephant seal "gives birth to young twice a year," but his observations on this point have been misinterpreted. He says mating begins in November, which is the beginning of summer; a second mating would mean a breeding season at the beginning of winter, which is incredible.

It is to be regretted that we did not bring back the skin of a nursing pup and the whole head and proboscis of a large male for anatomical study. In our desire to treat this unique herd with due consideration, we have relinquished, temporarily at least, the opportunity to thoroughly investigate the character of the proboscis. With the exception of the large female, the specimens procured were such as could be taken with the least possible injury to the herd as a whole. Some of the yearlings taken alive, I regret to state, have already become available for anatomical purposes.

The yearling frequently emits a sound not unlike the scream of the peacock. On first landing we were unable to account for these singular noises and ascribed them to sea-gulls, but soon discovered their true source. This call or scream is most frequently heard when the yearling is disturbed or trampled on by larger animals.

The taking of the live yearlings was a simple matter. Some heavy pieces of netting were thrown over the animals into which they were tightly rolled, so that the sailors could handle them without fear of being bitten or of their climbing out of the boats. On board ship they were for a time given the freedom of the decks, but later were kept in a pen. They showed no inclination to bite either while on the ship or when they were received at the New York Aquarium.

The photographs of the young animals taken at the Aquarium show some attitudes which were not observed on the beach at Guadalupe Island. Assuming that they were yearlings when captured at Guadalupe, they are now (February, 1912) twenty-three months old. While the animal is plump and rounded when at rest on the floor of the empty seal pool, it may look quite slim when stretching up its head to the hand of a visitor. The neck becomes remarkably drawn out, and it may reach upward until the tips of the flippers are lifted from the flooring.

Another attitude which the young animal takes at times, shows it balanced upon the stomach with the forequarters elevated until the tips of the front flippers are clear of the floor, the head turned far backward and almost touching the hind flippers which are lifted nearly as high as the head. It can also turn the head backward until the nose touches the floor. We did not succeed in getting photographs of these two attitudes.

Although handled but little, they are very amiable, only opening the mouth when approached too closely by the photographer. In swimming about the pool the fore flippers are seldom used. The animals often go to sleep under water, stretched out on the floor of the pool. The eyes of the elephant seal are remarkably large and lustrous. They are suggestive of the eyes of nocturnal animals, and it may be that the species is more active by night than by day.

Distribution Since 1880.

The number of elephant seals known to have been killed or captured in Lower California from 1880 to 1911 is shown in the following record:

1880	San Cristobal Bay, Schooner San Diego	30
1882	San Cristobal Bay, Schooner San Mateo	46
1883	San Cristobal Bay, Schooner ———	110
1883	Guadalupe Island, Schooner ———, Wentworth, Master	80
1884	San Cristobal Bay, Sloop Liberty, Morrison, Master	93
1884	San Cristobal Bay, Schooner San Diego	40
1884	San Cristobal Bay, Schooner Laura, Morrison, Master (C. H. Townsend in charge)	16
1884	Guadalupe Island, Schooner San Diego	4
1892	Guadalupe Island, Schooner Santa Barbara, Hunt, Master (C. H. Townsend in charge)	7
1904	Guadalupe Island, Schooner ———, Mullett, Master	4
1907	Guadalupe Island, Schooner Freia (C. M. Harris in charge)	14
1911	Guadalupe Island, U. S. S. Albatross, G. H. Burrage, U. S. N. Comdg. (C. H. Townsend in charge)	10
	Total	454

The above record is probably far from complete, as only 600 animals (including those now at Guadalupe Island) accounted for in forty or fifty years would be but slow increase for animals of the seal tribe. It is interesting to note that the record of killings as far as we have it, is limited to two localities, and one of these, San Cristobal, has yielded nothing since 1884.

Continued Existence.

The northern elephant seal has persisted as a race under the most adverse conditions. Its pursuit for oil as carried on prior to 1860 or possibly 1865, having nearly exterminated it, there

followed a period of comparative immunity during which its numbers slowly increased. Again subjected to persistent slaughter from 1880 to 1884, it disappeared for a time and was not seen until rediscovered at Guadalupe Island in 1892. Since then thirty-five elephant seals have been killed at Guadalupe for museum purposes. Had that island been visited by seal oil hunters, the elephant seal would probably not be in existence to-day.

Present Number.

When the *Albatross* left Guadalupe on March 4, 1911, there were not less than 125 elephant seals on the rookery. The breeding season having just commenced and the number of adult females present being considerably less than the number of adult males, and less than half the number of yearlings, there is reason to believe that the adult female portion of the herd would be better represented before the end of the month. The present size of the herd may therefore be estimated at 150 animals of all classes.

Eleven days later when the *Albatross* reached San Cristobal Bay on the Peninsula, I examined the site of the old rookery at that locality without finding any indication of its being occupied. We found no signs of elephant seals at either San Benita or Cedros Islands where the ship called on the voyage southward. I examined the shores of San Benita very thoroughly. Both of these islands were formerly breeding resorts of the species.

Distinctness of the Northern Species.

The specific distinctness of the northern elephant seal is well shown in the accompanying photographs of skulls of *M. angustirostris* and *M. leoninus* in the American Museum of Natural History. The skulls are those of adult males and both exceed twenty-two inches in extreme length, *angustirostris* being longer, while *leoninus* has the greater zygomatic width.

In the northern species the zygomatic arch is heavier throughout than in the southern species. In the former the jugal at its narrowest point has nearly twice the height of that of the latter, while its extreme length is considerably less. Its

upper posterior branch is higher and the inferior branch shorter than in the southern species. Its union with both maxillary and squamosal is decidedly less oblique and its upper portion is more strongly curved inward.

The frontal portion of the skull is much higher and narrower than in *M. leoninus.* The lower jaw is higher and its angle greater. Other aspects of the skulls show strongly marked differences, which appear also in the four other skulls examined.

Protection.

The northern elephant seal as we have seen, now breeds only on Guadalupe Island. Its numbers are slowly increasing and it is to be hoped that it will not be molested by seal oil hunters. The principal source of danger to this herd lies in the fact that its existence is now known in California where small-scale hunting enterprises to Lower California are sometimes organized.

The island is not inhabited and the Mexican government has not heretofore been interested in the protection of its animal life. It lies 140 miles off shore in latitude 29° 10′ N., and longitude 118° 18′ W., is twenty-one miles long and has an elevation near its northern end of 4,523 feet.

A plan was presented by the writer to the Secretary of Commerce and Labor, whereby the Guadalupe herd might be protected through United States customs houses on the Pacific coast by the refusal of clearance or entry to vessels dealing in seal products from Mexican waters. We also urged that the matter of protection of the elephant seals be brought to the attention of the proper authorities in Mexico with a view to securing concerted action. We are now informed that the Secretary of State has received information that the Mexican authorities have taken steps to prevent the killing of these seals, and the Secretary of the Treasury has been requested to assist in the work of protection through the administration of the customs.

New Information.

The observations made in 1911 on the elephant seal, together with the specimens and photographs which were secured, appear

to yield information on some features of its natural history which have hitherto been obscure. The following points may be noted:

The northern species is unquestionably distinct.

It now breeds only at Guadalupe Island and there are probably about 150 of the animals in existence.

The trunk of the adult male eighteen feet long, has a length of nine or ten inches forward from the canine teeth.

The trunk is not capable of inflation, but is retracted into heavy folds on top of the head by muscular action.

The breeding season begins a few days before March first and the period of gestation is twelve months.

The color of the young at birth is black.

The yearling emits a call or scream unlike the voice of any other seal.

The food preferred by the yearling and two-year-old in captivity is fish.

The yearling and two-year-old frequently lift the head and the hind flippers above the back until they nearly meet.

NOTE.—I have recently found in Blackwood's Magazine for December, 1818, some interesting information about the elephant seal of Tristan-da-Cunha Island, which lies in mid Atlantic in the latitude of the Cape of Good Hope. The article contains a letter written at Tristan-da-Cunha in 1811 by J. Lambert, from which I quote the following: "Sea-elephants . . . are plenty and they pup yearly, coming up in the months of August and September for that purpose. About a month or five weeks they take the male and then go off to feed, and in six weeks come up and remain a month of two to shed their old coat and get a new one, and from that time are for the most part lying in the sun asleep.

"The males, however, stay off longer, as they of course require a longer period to feed. Their food is chiefly kelp, but I have found squid in their stomach. . . . This last season I think 1,000 pups were brought forth on this island, and as many more on the other two, and I suppose when I passed near those islands they must have been almost innumerable, seeing some parties or other have been oiling here ever since and so many yet remain. If they are not disturbed for two or three years, the increase must be great and profitable, especially if their skins are attended to and salted.

"We have killed about eighty since we landed, and suppose we shall kill about two a week through the year. We have made about 1,000 gallons of oil. . . . The elephant in general makes about a barrel of oil, though some of the males will produce 100 gallons; of course there would be as many skins as barrels of oil, besides, at least, 1,000 pup skins, which are very fine and pretty, and would no doubt average a dollar each."

The Challenger Expedition did not find the elephant seal at Tristan-da-Cunha in 1873, the last having been seen, according to Moseley, "two years before."

FIG. 53. MALE ELEPHANT SEAL SIXTEEN FEET LONG.

Crawling attitude with proboscis relaxed and almost dragging on the sand. The hind flippers are usually trailed in progression on land.

FIG. 54. ADULT MALE ELEPHANT SEAL THROWING SAND ON HIS BACK.
The head is turned backward until the proboscis overhangs to the rear.

FIG. 55. MALE ELEPHANT SEAL THROWING SAND ON ITS BACK WITH FORE FLIPPERS. PROBOSCIS PARTLY RELAXED.

FIG. 56. MALE ELEPHANT SEALS APPROACHING TO FIGHT.
When within striking distance, both rear high on fore flippers, retract proboscis and open mouth very wide.

FIG. 57. ADULT MALE ELEPHANT SEAL. THE SNOUT IS SOMETIMES FLATTENED AND APPEARS VERY BROAD.

FIG. 58. ADULT MALE ELEPHANT SEAL CRAWLING INTO THE SURF.

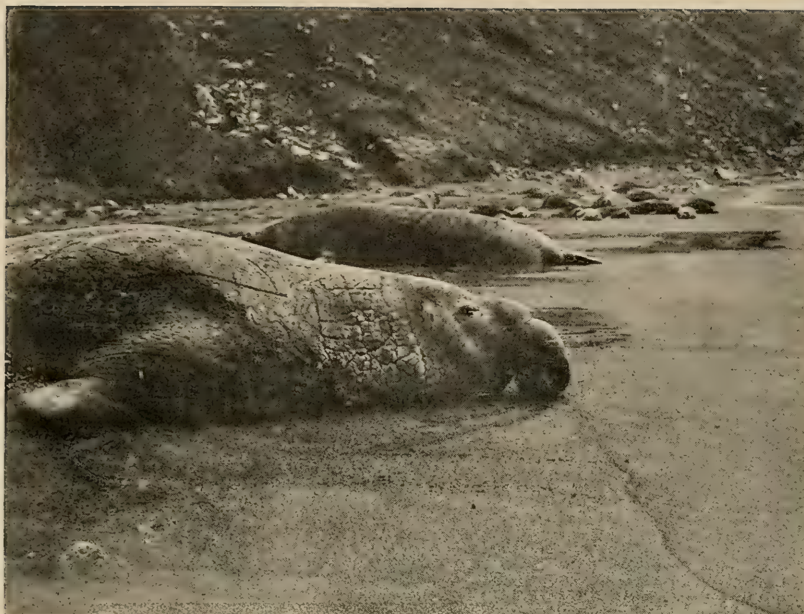

FIG. 59. ADULT MALE ELEPHANT SEAL SLEEPING—BODY AND SNOUT RELAXED, TIP OF SNOUT TURNED UNDER.

FIG. 60. ADULT MALE ELEPHANT SEAL.

The proboscis is drawn into heavy folds on the forehead, the back of the neck deeply wrinkled. The calloused shield of the neck and chest extends about half way round the neck. The fore flippers are powerful and easily raise the fore quarters from the ground.

FIG. 61. ADULT FEMALE ELEPHANT SEAL. UNDER EXCITEMENT THE NOSE IS PROJECTED INTO A POINTED TIP.

FIG. 62. VIEW OF BLACK PUP, SHOWING ITS EXCESSIVE FATNESS.

FIG. 63. ADULT MALE, ADULT FEMALE AND YEARLING.
The male is thoroughly aroused and in threatening attitude. The whiskers are erected and the mouth opened wide. The large canines are concealed by the pendant tip of the proboscis.

FIG. 64. ELEPHANT SEALS, ADULT MALES, FEMALE, BLACK PUP AND YEARLING.
Male at left with proboscis relaxed and its tip spread.

FIG. 65. ADULT MALE ELEPHANT SEAL WITH PROBOSCIS PARTLY RELAXED.
The eye is large and lustrous.

FIG. 66. SLEEPING IMMATURE MALE, YEARLING AND BLACK PUP.

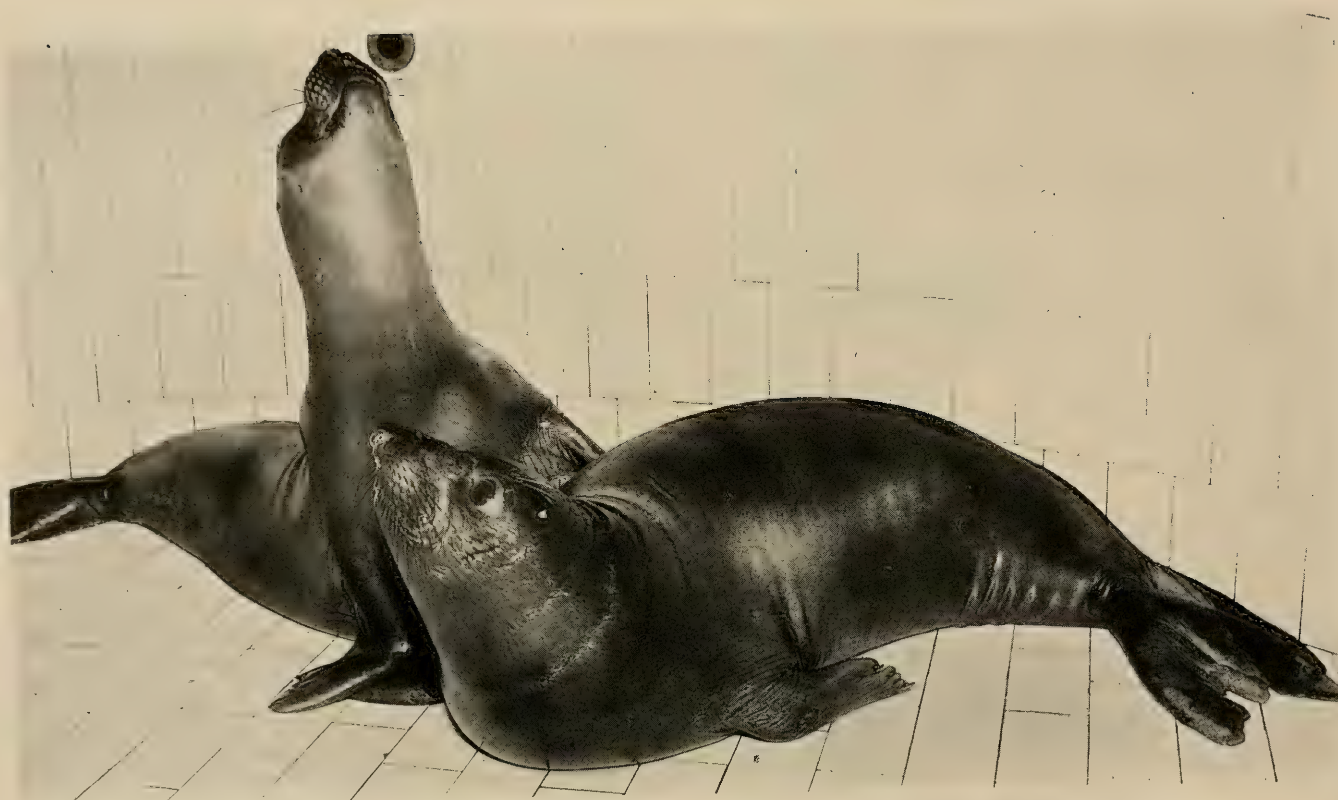

FIG. 67. ELEPHANT SEALS NEARLY TWO YEARS OLD IN NEW YORK AQUARIUM.

FIG. 68. ELEPHANT SEALS NEARLY TWO YEARS OLD IN NEW YORK AQUARIUM.
No other species of seal opens the mouth so wide when in threatening attitude.

FIG. 69. A PORTION OF THE COAST AT SAN CRISTOBAL BAY, LOWER CALIFORNIA, FREQUENTED BY ELEPHANT SEALS AS LATE AS 1884.

The animals generally occupied the mouths of the gullies, the beaches under the bluffs being narrow. The coast of this part of the Peninsula is totally lacking in fresh water for a distance of over 100 miles, and has always been uninhabited.

FIG. 70. NORTHWEST SIDE OF GUADALUPE ISLAND, AT DISTANCE OF ONE MILE.

Small beach occupied by elephant seals is in center of picture, near large rock slide.

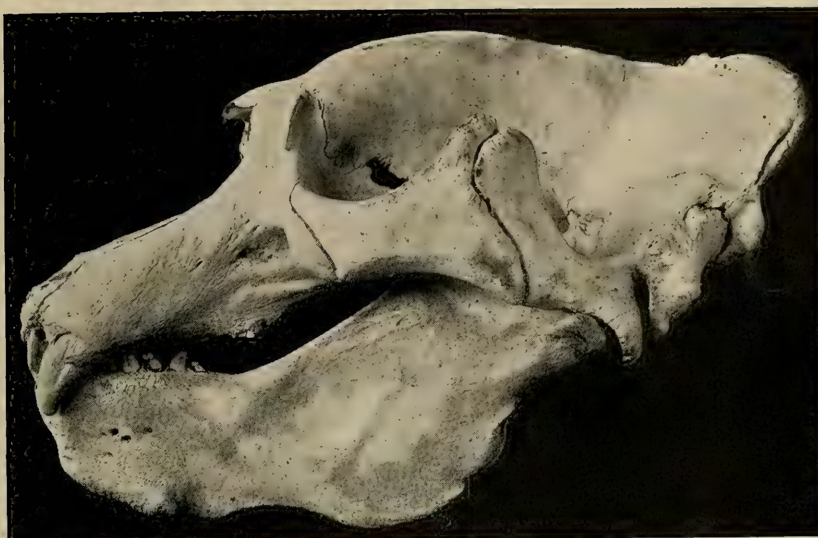

FIG. 71. SKULL OF ADULT MALE *MACRORHINUS ANGUSTIROSTRIS,* FROM GUADALUPE ISLAND, LOWER CALIFORNIA.
Extreme length 23⅝ inches, extreme zygomatic width 13⅞ inches.

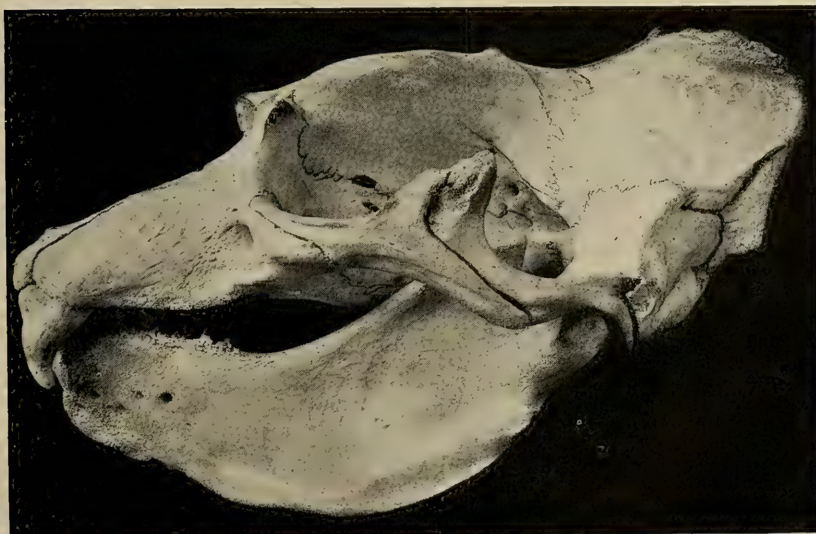

FIG. 72. SKULL OF ADULT MALE *MACRORHINUS LEONINUS,* KERGUELEN ISLAND, ANTARCTIC.
Extreme length 22¼ inches, extreme zygomatic width 14½ inches.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE
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VOLUME I, NUMBER 9.

SOME COMMON AFFECTIONS OF THE RESPIRATORY AND DIGESTIVE ORGANS AMONG PRIMATES

By

W. REID BLAIR, D. V. S.

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FIG. 73. CHIMPANZEE RECEIVING INHALATIONS OF MEDICATED VAPOR

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Frontispiece

SOME COMMON AFFECTIONS OF THE RESPIRATORY AND DIGESTIVE ORGANS AMONG PRIMATES

By W. Reid Blair, D.V.S.

INTRODUCTION.

In the examination of sick animals it is important to have a definite method or system. A plan of examination should be followed, so that when that task is finished there shall be no important point overlooked; then the examiner is in a position to form an accurate opinion.

A thorough knowledge of conditions that obtain in the healthy animal is of the highest importance, because it is only by a knowledge of what is normal that one can detect the abnormal. A careful study of different species of animals throughout their growth and development, by the individual with good powers of observation and a reflective turn of mind, is of great value. A thorough knowledge of anatomy, the structure of the body, and of physiology or the functions and activities of the body, also lie at the foundation of an accurate diagnosis.

Of course an experienced eye can detect slight alterations or variations from the normal that are not perceptible to the unskilled observer. He who is most familiar with the appearance and deportment of a wild animal in health, at the various periods of its existence, will be in a position to most readily appreciate all departures from the normal. It is also important to know that all animals of different races and families deport themselves differently under the influence of the same disease or pathological process. For instance, a degree of fever that does not produce marked dullness in a nervous, highly strung chimpanzee, may cause the most abject depression in a coarse, plethoric orang-utan. The same is true of many other

species of wild animals. This, and similar facts are of the greatest importance in the diagnosis of disease and in the recognition of its significance.

History.

Before making an examination of a patient, the history of the case is obtained from the keeper. This is very important. Upon this feature alone a fairly safe diagnosis may often be made by the experienced observer. It is important to know something of the origin and development of the disease. The *cause* of a disease is important, not only in forming a diagnosis, but also in connection with treatment; therefore it should be carefully sought. The character of the food and water, the temperature of the building and the care that the animal has received should all be inquired into closely.

The examination of the sick animal may be *general* and *special.* The former refers to symptoms which involve the whole organism, the latter considers the single organs of the body, the secretions and excretions.

In making a general examination the following points should be observed:

1. The physical condition of the patient.
2. The constitutional and nutritive condition.
3. The mucous membranes and the skin.
4. The respiration, temperature and pulse, when the two latter may be obtained without causing undue excitement.
4. The position of the animal when lying down is to a certain extent a diagnostic symptom; very sick animals will not rise when approached. Animals that are affected by lateral or one-sided diseases of the chest—lateral pneumonia or pleurisy—most frequently lie on the affected side; while those cases where there is difficult or labored respiration, as in double pneumonia or fluid in the chest, remain standing with the forelegs well spread, or they assume a sitting position.

The constitutional condition may depend, to a large extent, on the age of the animal, length of time in captivity, how it has been fed, and the amount of exercise it takes; but as a general rule if the animal is in poor condition, it is usually due to the presence of some disease. The skin, to a certain extent, is a good diagnostic guide; if the animal enjoys good health the skin will be loose and easily

pulled from different parts of the body. In very slight cases of emaciation one must depend, to a certain extent, on the history of the case as obtained from the keeper. A rapid emaciation occurs in diseases of the digestive tract; in all acute or chronic feverish affections, and in certain cases of poisoning.

The visible mucous membranes are examined as to their color. Abnormal paleness may be due to anæmia or internal hemorrhages, or defective heart action. A blue (cyanotic) coloring is sometimes observed where there is defective oxygenation of the blood; pressure on the larynx or trachea; in pneumonia, and in certain heart affections, especially fatty degeneration of the cardiac muscle.

A yellow color (icteric) generally denotes some disorder of the liver, and occurs in certain infectious diseases. The changes in color of the skin are most readily detected where the hair is thin, as on the belly and the inner surfaces of the thighs. A very red skin indicates a high temperature or the commencement of some skin eruption; if yellow, some disturbance of the liver or portal system is to be suspected.

The hair is also a useful guide in diagnosis. In sick, poorly fed or neglected animals, or those infested with parasites, it loses its gloss, becomes dry and brittle, and in some cases falls out partially or entirely.

Oedema or dropsy of the skin is an abnormal accumulation of fluids in the skin and the subcutaneous cellular tissues. If the swelling be pressed by the finger, the indentation remains visible for some time; this may come from a number of diseased conditions. The swellings are chiefly confined to the lower portions of the body, as the extremities, abdomen and under the chest. It occurs as a complication in diseases of the heart, especially where there is imperfect valvular action, and in acute kidney disorders, and prolonged acute affections.

The temperature of the body is determined by what is technically known as the blood or clinical thermometer. The thermometer is introduced into the rectum and allowed to remain from two to four minutes, according to the sensitiveness of the instrument. In most animals the temperature is highest at five o'clock in the afternoon, and lowest at about the same hour in the morning. An increased temperature of the body above the normal, not due to overheating or to great exertion, is defined as fever.

A fever, as a rule, begins with a chill or a number of them. There is a shivering or quivering of the muscles and skin and finally of the entire body. If the temperature is high, the animal becomes weak and falls away in weight very rapidly. Increase or decrease of local temperature is generally due to some injury, or a surgical disease.

RESPIRATORY SYSTEM.

Nasal Catarrh.

This affection, generally spoken of as cold in the head, is indicated by a watery or thick, mucoid discharge from the nose and eyes, and is due to a febrile or inflammatory condition of the mucous membranes of the nasal chambers or the frontal sinuses, which may arise from damp, cold or contagion.

Symptoms:—Frequent sneezing, nasal and lachrymal discharge, cough, dullness and inclination for warmth.

Treatment:—Acute catarrh is usually transient and does not often require local treatment. Steaming the head with eucamphol will afford soothing relief if the head is very stuffy from becoming clogged with the collected discharge. Vaseline rubbed into the nasal openings prevents the hard, dry, irritating crusts forming as the result of the discharge from the nostrils.

If the animal can be taught to use a blanket to sleep in, these annoying nasal colds will generally be avoided. Careful regard as to warmth and comfort will generally suffice to prevent them.

Laryngitis. Pharyngitis. Sore Throat.

Animals affected:—Primates generally.

Causes:—Chiefly faulty hygiene; infection of influenza.

Symptoms:—There is usually more or less difficulty in swallowing, swelling around the throat and under the ears, husky cough and tenderness on pressure. The inspiratory act is accompanied by a rasping or deep bass sound, particularly after the slightest exertion. There is sometimes the general symptom of fever more or less marked, with hastened breathing and red-injected eyes and nostrils.

While sore throat is rarely fatal in primates, its effects are not unimportant or trivial. It occasionally merges into a chronic form,

with a troublesome, hacking cough, tenderness to pressure and an increased liability to diseases of the air passages.

Treatment:—A roomy, clean, dry cage should be allowed, care being taken to avoid draughts of cold air, and to secure a soft equable temperature of about 70°. The throat should be well, but gently, rubbed with camphorated oil. Inhalation of eucamphol or compound tincture of benzoin in hot water, should be given every two hours. If the cough is troublesome, a few grains of Dover's powder should be given two or three times a day. The diet should be confined to warm, nourishing gruels or milk and brandy, sweetened lemon juice or coffee. In cases attended with high fever and bright red nasal membrane, laxatives and diuretics are especially needed. Ten drops of the fluid extract of cascara sagrada should be given at the outset, and five grains of acetate of potassium given twice daily, allowing the animal to drink all the warm water possible.

Bronchitis.

This disease is an inflammation of the mucous membrane of the bronchial tubes. When the smaller bronchial tubes are involved, the affection is termed *capillary bronchitis,* and this form is most common in very young, very old or debilitated animals. The disease is exceedingly common among all primates, and especially so in the chimpanzee.

Causes:—Bronchitis may arise from irritating dust inhalation, exposure to damp and cold and sudden changes of the temperature of a building.

Symptoms:—Quick wheezing respiration, frequent and prolonged coughing. The cough at first dry, later becoming moist and thick. The eyes become red and inflamed and there is usually considerable sneezing with nasal discharge. The heart beats are greatly increased, and on placing the ear to the animal's chest, a moist rattle is heard. The animal becomes prostrate, and unless speedily relieved, quickly succumbs to broncho-pneumonia or asphyxia.

Treatment:—The patient should be placed in comfortable atmosphere, free from draughts or dampness. Mild cases are relieved by inhalation of a sedative steam arising from a pail or steam evolved from an ordinary human bronchitis kettle. When treating animals which are easily controlled, or confined, little difficulty will be ex-

perienced in carrying out this treatment, as the patient quickly appreciates the relief afforded. Extremely bad cases in chimpanzees and orangs have been treated successfully in this way. Ferocious animals may be confined in a small cage or shifting box which can be covered with a blanket or canvas for the purpose of confining the steam.

The steaming should be continued for only a few minutes at a time, but repeated several times a day.

The food should be nutritious and concentrated; bulky food should be avoided. The sweetened juice of oranges and lemons is very beneficial and should be given quite freely.

The throat and chest should be well rubbed with camphorated oil, when possible. In all forms of bronchitis, counter-irritation and the chest-jacket are very useful.

Inhalations of compound tincture of benzoin, or eucamphol mixed with water, in the proportion of one tablespoonful to a cup of water, will be found most useful. Eucamphol is a compound composed of carbolic acid, oil of camphor and eucalyptus oil. It has a very pleasant odor, which is acceptable to the animals and it is very soothing to the bronchial mucous membranes.

When the cough is very troublesome and harsh, give a mixture of carbonate of ammonium with Brown mixture, as follows:

℞

Ammonium Carbonatis........................ʒii
Misturæ Glycyrrhizæ Comp. (Brown Mix.)..........℥iv

M.

Sig:—Give a half-grown chimpanzee ½ teaspoonful every 4 or 5 hours, in milk or the juice of orange.

Pneumonia.

Pneumonia is an inflammation of the substance of the lungs, and may be confined to a portion of one lobe or may include the greater part of both lungs. It is a disease that carries off a considerable portion of all wild animals in confinement, both as a primary affection, and as a complication of other diseases, especially those of a debilitating character.

Among primates, the most common type met with is broncho-pneumonia, in which only limited and usually scattered portions of the lungs are involved.

FIG. No. 74. CHIMPANZEE SUFFERING FROM PNEUMONIA, WITH CHEST JACKET APPLIED.

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Causes:—The onset is favored by exposure to cold or anything inducing a chill. Microscopic examination of the discharges coughed up shows, in many cases, an abundance of various bacteria of infectious nature. These examinations have convinced me that in the treatment of this disease, it is safe to regard all cases as infective. This type of pneumonia is most common as a complication of bronchitis.

Tuberculous broncho-pneumonia of primates will be spoken of under tuberculosis.

Symptoms:—The usual preliminaries are frequent shiverings and general febrile disturbances shown by increased temperature and high pulse. The breathing is seen to be short and gasping, and an irritable cough is present. The eyes are red, and the nose hot and dry. On placing the ear to the animal's side, increased lung sounds are heard, which ultimately become obliterated as the disease proceeds, as a result of the filling up of the air spaces with congested blood. If only one lung is involved, the animal will lie on the affected side, thus allowing the sound lung to be relieved of all possible pressure. In pneumonia too great reliance cannot be placed on physical signs alone, as there may be very grave disease without the former being at all well pronounced. Prostration with very slow or very rapid heart action are indications calling for the most watchful treatment, especially if with these there is much difficult breathing, and blueness of the mucous membranes, indicating that the blood is being very poorly ventilated.

Treatment:—This consists of active counter-irritation to the sides of the chest, diffusible stimulants, bodily warmth, free ventilation, and nourishing food. In all forms of lung affection counter-irritation combined with a "chest-jacket" will be found of great value.

The object of a chest-jacket is to have a close-fitting coat or bandage, which shall absorb the moisture from the animal's skin and protect it from variations in the external temperature. The exact construction is of minor importance, provided it is of even thickness, fits closely, and can be kept in place. In winter it may be made of two layers of flannel, with or without padding of cotton-wool quilted in. Openings may be made for the forelegs. Closeness of fitting without being so tight as to embarrass the breathing is important, both to preserve it in position, and to prevent the access of cool air.

Often the animal will breathe easier at once when the dressing is applied. The food should be light at first, unless there be marked prostration, and largely fluid while the fever is high. Alcohol baths are useful in reducing excessive temperature.

If there is evidence of pain a few grains of Dover's powder, on account of its favoring the action of the skin and kidneys, will be found beneficial. If the disease is of a low type from the first, with evidences of great weakness or positive prostration, the chief reliance must be on good feeding and alcohol, with such stimulants as carbonate or muriate of ammonium, strychnine or caffein. Whiskey or brandy, given in doses of a teaspoonful or less with beef juice or eggnog, if the animal refuses nourishment, or diluted with water, given simply as a medicine, often produces the happiest effects. If the animal will not take nourishment it must be forced upon it, if possible, with as little exhaustion of its strength as necessary.

If the heart becomes very weak or irregular, resort must be had to digitalis, say three to five drops for a half-grown orang or chimpanzee. It is a most valuable remedy in careful hands. Death in pneumonia is nearly always by heart-failure, and this organ must therefore be carefully observed throughout. During convalescence, if the appetite is not good, vegetable bitters—as nux vomica and gentian will be useful. Quinine is a well-tested and safe remedy for monkeys generally, and small tonic doses—one to two grains—may be given three times daily.

DISEASES OF THE DIGESTIVE SYSTEM.

Indigestion.

Vomiting, Gastritis, Stomach and Intestinal Parasites, Gastroenteritis. Prolapsed Rectum.

The term *indigestion* implies imperfect discharge of the functions of the digestive tract. The symptoms may manifest themselves without actual structural or organic disease of the digestive organs, being visible to the naked eye. The cause is generally improper diet. Indigestion also arises from diseased teeth and imperfect mastication. Cold, heavy and soggy rice, due to improper steaming will cause acute colic pains.

Few monkeys are proof against the temptation to overeating.

Some are natural gluttons and on gaining access to food, will rapidly overload the stomach. The food is literally bolted whole, with no admixture of saliva, and no facility for admixture of the gastric juices, even if the overloading had left the stomach capable of secreting the latter.

Symptoms of Indigestion:—Uneasiness, pain, abdominal distension, labored breathing due to the distended stomach pressing hard against the diaphragm.

Treatment:—The diet is usually the first matter to be considered, and if it is rich and stimulating, should be replaced by easily digested materials.

In many of these cases we have found that special dieting or positive abstinence from food for a time, proves most serviceable. A little warm milk with one-fourth of lime-water has a marked corrective effect in these cases. If there is much distension of the abdomen, aromatic spirits of ammonia with subnitrate of bismuth should be given. Gentle hand-rubbing of the abdomen with warm cocoanut oil, and warm-water; rectal injections are useful, if constipation is also present.

Gastritis, Enteritis and Dysentery.

Among primates the most important diseases of the digestive system are *gastritis,* or inflammation of the stomach; *enteritis,* or inflammation of the small intestine; *dysentery,* or inflammation of the large intestine.

Instead of giving a systematic description of each of these affections, we propose to direct our remarks as to how to discriminate between them, and with special reference to treatment.

The common causes are generally unsuitable food; either too coarse and bulky, too stimulating, or too hot or too cold. Food that has soured by lying over night in the cage and then eaten by the animal is very prone to set up gastric disturbances.

Symptoms:—The symptoms of these affections are much the same, and may also be conveniently grouped. One of the marked symptoms of these disorders in the domestic animals is *vomiting.* Among primates vomiting, except on rare occasions, seldom occurs. It is most difficult for a monkey to relieve its stomach by vomiting. When vomiting is observed in these animals, the presence of some irritating food or poison should be suspected. Large round worms in the

stomach have been known to induce violent vomiting. If the vomit consists of mucus stained with dirty yellowish bile, tuberculosis of the liver is to be suspected. Foreign bodies, such as pieces of blanket, sticks, or nails which are apt to lodge near the pyloric opening of the stomach, also induce vomiting.

In gastritis and enteritis, pressure on the abdomen shows pronounced tenderness or pain, whereas, with the colicy pains of indigestion, by massaging the abdomen the pain is appreciably lessened. The appetite is somewhat modified, and soon after the animal has partaken of food, it will be uneasy and isolate itself; thirst is pronounced; the bowels moving frequently; the fæces at first are very soft and later the evacuations are composed of fluid and mucus which may be streaked with blood. At this stage the animal becomes very weak, and emaciation is rapid.

When the large intestine becomes involved, the fæces are generally fluid, frequently blood-stained, and usually passed without effort.

Treatment:—In beginning treatment for acute diarrhœa or dysentery, it is always wise to give a dose of castor oil or olive oil, in order to make sure that the bowels are free from irritating substances. A few drops of tincture of opium to relieve the pain should be added to the oil. This treatment alone will frequently be found to effect a cure. If the symptoms with diarrhœa persist, then small doses of paregoric and subnitrate of bismuth should be given every few hours. All solid food should be withheld. The whites of eggs beaten up in milk, with the addition of a teaspoonful of blackberry brandy, should be the principal food for the first few days. A few drops of tincture of opium in a little barley-water is also of value when the stomach is very sensitive.

The return to solid food should be most gradual and approached with the greatest care, as the gastric and intestinal mucous membranes remain in an extremely sensitive condition for a considerable period after these affections. A tablespoonful of lime-water added to each four ounces of warm milk will be found to be of great benefit while the stomach remains sensitive.

Prolapse of the Anus.

This condition denotes an eversion of the lower portion of the rectum, and its protrusion through the anus. The affection may be

seen in almost any animal, but has been most frequently observed among monkeys suffering from dysentery, or anything which will cause the animal to unduly strain, as in chronic constipation or any laxity or weakness of the external sphincters. Simple prolapsed rectum is easily recognized as such. A typical protrusion presents the appearance of a curved cylinder with the mucous membrane considerably swollen. In the early stages the protruding tissue is covered with mucus and prone to bleed on coming in contact with the rough hay or straw of the bedding.

Treatment of eversion of the rectum in some cases will be most difficult; but in other cases very simple. When the everted rectum has not become congested, it may be returned to its proper position by a little lubricant.

If any difficulty is experienced, the fore-finger should be well oiled, and by a digital kneading process, commenced at the extremity of the protrusion, the latter is gradually worked through the anus into the proper position.

Tannic acid, one part, and vaseline, five parts, should be smeared over the rectal mucous membrane, and all food should be withheld from the animal for at least twenty-four hours, and then milk with twenty to thirty grains of sulphur given twice daily.

Infective Ulcerative Dysentery in Apes.

During 1901 there occurred an epidemic of dysentery among the orangs, which also affected a chimpanzee, with the result that all of these animals, five in number, died.

From the coincidence of four or five cases occurring at the same time, acute intestinal irritant was suspected, and as the apes had been receiving small quantities of cod-liver oil, it was thought that the irritant matter might have been introduced through this medicine.

The cases proved obstinate and the disease progressed steadily from the beginning, although one or two of the cases yielded temporarily to treatment.

Many of the best known intestinal antiseptics were administered under the direction of Dr. Miller. These included salol, subnitrate and sub-gallate of bismuth, xeroform, opium, etc., but all proved equally ineffectual. Irrigation of the colon by enemas of sterilized

normal salt solution, and quinine bisulphate were administered without appreciable result.

The disease progressed steadily, the animals dying within a few days of each other. The post-mortem examinations were made by Dr. Brooks, who was able to identify the cause of the disease to be the invasion of the intestinal mucosæ by the *Balantidium coli* (*Paramœcium coli*), a parasite belonging to the Order *Heterotricha*. This organism was discovered by Molmsden in 1857, in the mucus discharges of a patient who suffered from a persistent diarrhœa following cholera. The *Balantidium* is an oval body, about six or seven times the diameter of a human red-blood cell; is quite actively motile, but soon ceases its movements if exposed to cold, acids, or disinfectants.

The lesions produced by the *Balantidium coli* are principally confined to the large intestine, where in the case of the orangs, the entire mucous membrane of the colon was transformed into an almost continuous succession of large irregular ulcers. Microscopic examination of sections of these ulcers showed myriads of parasites burrowing beneath the mucous membrane, even along the lymphatic channels of the muscular coat and in places as far down as the peritoneum.

Just how this deadly protozoan first reached the apes remained for several months a complete mystery. A diligent microscopic search of the fæces of all possible sources of immigrat on was finally rewarded by the startling discovery that the fæces of the giant tortoises from the Galapagos Islands, exhibited during the summer in a yard surrounding the open-air cages of the orang-utans, were swarming with *Balantidii* but which had not caused these reptiles the least inconvenience.

Owing to the danger of this parasite to the higher apes, and the unsatisfactory treatment, it is important that an early diagnosis should be made in suspected cases of dysentery in apes, in order that strict isolation of infected ones should be carried out. An easy and positive examination may be made by microscopic examination of the fæcal discharges of infected animals when the actively motile *Balantidii* are to be seen.

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NEW BLOOD PHEASANTS

By

C. William Beebe
Curator of Birds

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NEW BLOOD PHEASANTS

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The Blood Pheasants forming the genus *Ithaginis* fall into three groups which until recently have each been represented by a single species. *Cruentus* has the throat crimson and the breast streaked with the same color and with a faint green wing patch; *geoffroyi* has the throat and breast blue-grey and the wing patch vivid green; *sinensis* combines with a pale buff breast, wing-coverts of golden brown or bright rufous.

One day in northwestern Yunnan, in December, 1910, I noticed a Chinaman passing along the trail driving a number of forlorn horses with some heavy merchandise. Under the thongs which fastened one of these loads was tucked a bedraggled mass of feathers. A glint of scarlet caught my eye and I stopped the man and examined the plumage. I saw at once that it was the remains of a Blood Pheasant, and consisted of a large patch of breast feathers almost wholly scarlet and black, and two detached wings with the typically long, loose, bright green coverts of *geoffroyi*. I secured the plumage and learned that the man had obtained it from a native farther to the north. He could not say certainly whether all the plumage came from a single individual, and although I realized its great interest, it was impossible to put any exact interpretation upon it at the time.

While studying the specimens of pheasants in the museum of the Jardin des Plantes here in Paris I have come across two mounted specimens which clear the matter up, and show that the Blood Pheasant from the extreme northwest finger of Yunnan is a very well-marked form, by far the most beautiful and brilliantly colored

of its genus. Lacking any data as to intermediate specimens I give it full specific rank.

Ithaginis kuseri sp. nov.

Entire forehead, chin, throat and sides of the head crimson. A narrow collar of black feathers with crimson fringes crosses the upper breast, merging at the sides with the blue-grey of the mantle. Posteriorly the breast, upper belly and corresponding sides of the body are intense crimson, marked only with very narrow shaft-lines of pale green. Behind this area the lower belly and sides down to the thigh, are brilliant clear, apple-green.

The whole head is chiefly black with no white or cream color except a trace on the nape. The upper body plumage is uniform blue-grey, with conspicuous shaft-stripes, white without any tinge of green. The wing-coverts are bright, clear green throughout, and the middle and greater coverts are very long, with recurved, decomposed barbs. Black is wholly lacking on the visible portion of these coverts, the only character being the slightly paler green shaft-stripe. The concealed bases show a rufous-brown tinge, while still more basally the feather becomes blue-grey with the narrow black lines bordering the shaft. The covert and tail fringes of crimson are well developed and the under tail coverts are brilliant crimson.

The description is of the specimen here designated as the type and is a fully adult male bird, No. 179A in the mounted collection of the Museum National D'Historie Naturelle. It is marked "Yunnan. Prince H. d'Orleans, 1896". Measurements in inches of this specimen are culmen 43; wing 8.5; tail 5.2; tarsus 2.5; middle toe and claw 2.1. There are two spurs on the right leg and a single one on the left, each about half an inch in length. The specimen is considerably moth-eaten and in a bad state of preservation.

A second specimen of *Ithaginis kuseri,* the only one, except my fragment, of which I know, is No. 179B in the same collection. It is a young bird in its first year, the spurs being mere flat nodules. It corresponds in all respects with the type, except that there is an even greater infusion of black throughout the plumage. The tail, which is more perfect than in the other bird, is an inch longer. Its label gives "Tsékon, Yunnan. R. P. Soulie, 1897". This locality is in the northwestern finger of Yunnan on the Mekong River, in

latitude 28° north, and longitude about 99° east, thus giving a definite location for the species.

The bird combines some of the characters of *cruentus* with the brilliant green wing patch of *geoffroyi*, but it differs in many ways from both. From Himalayan birds it at once stands apart as almost lacking the white or cream color on the anterior part of the body, in the remarkable amount of crimson, and in the *geoffroyi* type of wing.

I take great pleasure in naming this well-marked species in honor of Col. Anthony R. Kuser, whose interest and generosity have made possible these pheasant researches.

Heretofore we have known of no specimen of Himalayan Blood Pheasant east of extreme western Bhutan, while *Ithaginis geoffroyi* ranges through southeastern Tibet and touches the extreme tip of Yunnan. It has been remarked more than once that the eastern specimens of *Ithaginis cruentus* differed appreciably from those ranging more to the west, chiefly in the large amount of crimson streaking on the breast of the western or Nepal birds, this color being absent or very faintly indicated on birds from southern Sikhim.

After careful consideration, and for a number of reasons I think this fact worthy of permanent record and accordingly establish a sub-specific designation for the eastern and more southerly form.

Ithaginis cruentus cruentus (Hardwicke)

The male type specimen from Nepal, named *Phasianus cruentus* by Hardwicke in 1822, and now in the British Museum, is typically of the heavily streaked, western form. The crimson is very heavy and abundant on the breast, starting well up on the lower throat, while on the center line of the breast and laterally as well, the crimson spots are scattered over much of the ventral plumage, traces being present even on the long flank thigh feathers.

Ithaginis cruentus affinis subsp. nov.

Looking at a large series of Blood Pheasant skins from Nepal and northern Native Sikhim, the eye at once notes three distinct zones of crimson on the ventral surface, chin, mid-breast and under tail coverts. A second series of birds collected in southern Sikhim and "near Darjeeling" shows the central zone absent or nearly so.

For example, in one such series, only six out of sixteen birds showed superficial traces of the crimson color, in the majority this hue being represented only by faint rusty stains on a few of the feathers.

In the present sub-species there is also a decided reduction in the crimson fringe on the upper tail-coverts and rectrices. A constant character separating the two forms is that in *cruentus affinis* the two outer pairs of tail feathers wholly lack the crimson, while in *cruentus cruentus* only the outer pair lacks this color, the second pair being invariably tinged and often fringed with crimson. There is no very decided differentiation in size, although the average of measurements of a large number of specimens shows the typical *cruentus* form to be slightly smaller than *affinis.*

As type of this sub-species I designate an adult male, collected in British Sikhim, Kuser-Beebe Collection, No. 387. This bird will ultimately be included in the collection presented by Col. Kuser to the American Museum in New York City.

It is important to note that many Blood Pheasants have been collected and sent to Museums with the simple locality "Darjeeling," and a number of these are more typically *cruentus* than *affinis.* This species has never existed in the vicinity of Darjeeling or even in the Darjeeling district, and the supposition is that these particular specimens were collected far north as the Singhaleela Range, which forms the divide between Nepal and Sikhim. Birds from this range with direct communication northward around the slopes of Kinchinjunga with the central Nepalese mountains we should expect to be more typical of *cruentus* than *affinis.*

In regard to the females, those from Nepal show on the whole much more crimson than birds from Sikhim. Taking the character of a distinct crimson band around the facial area and a noticeable crimson wash or tinge on the chin and throat, the proportion of its presence in typical *cruentus* from Nepal is about 85%, as against 10% of occurrence in southern Sikhim birds and even this small percentage is based on doubtfully labelled specimens.

Even more diagnostic a character is the crimson color on the margins of the rectrices, which I have never found absent from a Nepalese female, while of southern Sikhim birds not one in ten has the faintest trace. A typical *affinis* female is slightly greyer in general tone than the western form, this being especially noticeable on the lesser wing feathers, where the lighter markings are

decidedly whitish instead of warm buff. The type specimen selected is the adult female from southern Sikhim, which is No. 450 in the Kuser-Beebe Collection.

The form *Ithaginis cruentus affinis* is of the same geographical class as *Phasianus soemmerringii ijimae,* but with more claim to recognition and record, as the latter is closely associated with *P. s. scintillans* in a broken country easily transversed by the birds in all directions, while *Ithaginis cruentus affinis* is found only at the southern extremity of narrow mountain ridges, separated by deep valleys which are never transversed by these lovers of high altitudes. Indeed at the present time this form may be considered all but extinct.

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VOLUME I, NUMBER 11.

THE FEEDING HABITS OF SERPENTS

By

RAYMOND L. DITMARS
CURATOR OF REPTILES

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FIG. 75. GRAY COLUBER, *Coluber obsoletus confinis*

Inhabits the southern United States. It represents a genus composed of species of marked economic importance. The prey is overpowered by constriction

THE FEEDING HABITS OF SERPENTS

By Raymond L. Ditmars.

INTRODUCTION

From a series of observations embracing a period of many years the writer has drawn the conclusions and prepared the notes herewith presented. He has been particularly fortunate in the possession of elaborate material in pursuing his studies of a zoological specialty. Ten years prior and up to the time of assuming charge of the reptiles in the Zoological Park, the writer maintained a large collection of living serpents, with which his investigations permitted the observation of *individual* examples. Such work is of great value, yet largely impossible in the care of a great collection like that we have installed in our Reptile House. However, in the latter comes the ability to maintain a thoroughly representative series of subjects with the consequent possibility of comparison of habits. All phases of serpent life relating to habits and structure have been represented in the collection of the New York Zoological Society. Yet this very elaboration of exhibition, so instructive to our visitors, is detrimental to the condition of the reptiles, as it renders individual attention impossible and thereby shortens the life of the greater number of specimens.

Quite different from other vertebrates, the feeding of snakes is so influenced by temperature, light, the nervous condition of the reptile, or the slightest ill-health, that any of these causes slightly deviating from the normal will result in an abrupt cessation of feeding. It is possible to produce normal conditions and induce steady feeding with but a comparatively small proportion of snakes,—about half of the total number of species that it is possible to obtain for exhibition. Some feed irregularly, and their lives as captives are short. There are representatives of a few species that never have been induced to feed in captivity. The latter are mostly poisonous snakes.

The development of the nervous organization appears to play an important part in the feeding habits. The most highly specialized types, the viperine poisonous snakes, possess a highly sensitive nervous organization and for the most part are short-lived under observation. It is among these reptiles that we note mystifying habits, and among representatives of some of the species, an utter disinclination to feed. Though provided with deadly, venom-conducting fangs, and an amazing dexterity in the use of these weapons both in obtaining food and in defense, these formidable creatures invariably remain more timid than their innocuous allies which become readily accustomed to change of environment.

In preparing this *resume* of a considerable series of genera and species, the writer hopes that it may contribute something toward a solution of some of the problems of evolution and relationship which fall to the lot of the systematist.

While considering the feeding habits of an extensive order like the *Ophidia*, some of the members of which cling to ancestral characteristics, while others have become highly specialized, a first impression might lead the novice to presuppose the existence of a great variety of foods. This is not actually the case. The food of serpents is considerably less elaborate than of the Order that embraces the ancestral forms of the snakes, the lizards. The point of primary importance to be noted is the fact that serpents are carnivorous and a few insectivorous; no species of snake is known to be herbivorous. Among the lizards the herbivorous species exist in large number. This is also the case with the latter Order in regard to insectivorous species. There are few species of insectivorous serpents, however, and the habit is noted as occurring arbitrarily among both small species of directly ancient lineage and others which are markedly specialized.

The great percentage of serpents feed upon forms of vertebrate life. A large number feed exclusively upon mammals and birds, and a like proportion subsist entirely upon cold-blooded vertebrates. There are many species with feeding habits not so well defined and which feed upon either mammals, birds, reptiles or batrachians; these we will term *omni-carnivorous* species. Many species are cannibalistic and a few feed altogether upon eggs.

In the development of serpent life, even among the crudest forms, we immediately note the great modification of the structure of the

FIG. 76. RATTLESNAKE DIGESTING A MOUSE
The great elasticity of the swallowing mechanism enables the serpent to consume, without mastication, prey that is four to six times the diameter of the reptile's neck

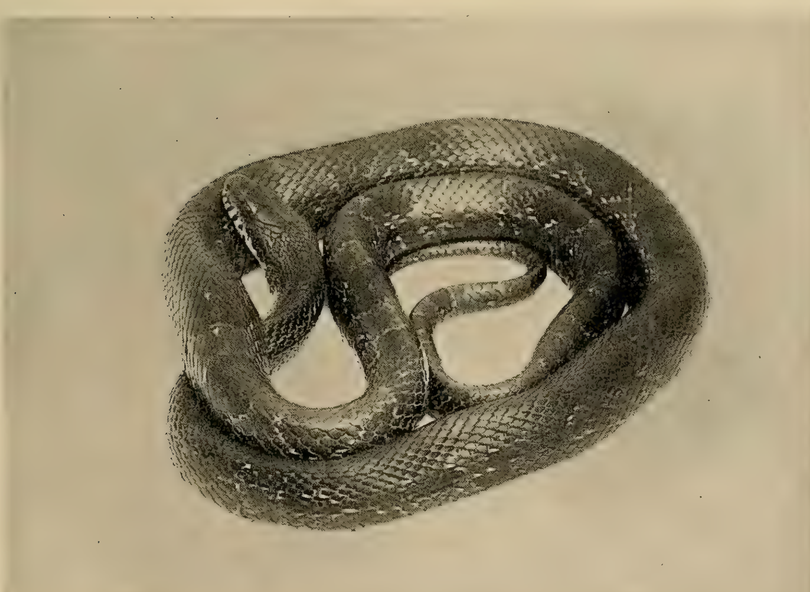


FIG. 77. CORN SNAKE, *Coluber guttatus*
A typical constrictor. Inhabits the southern United States

jaw bones, this pointing to carnivorous habits. Among the highly specialized types of the later groups, this modification has developed into a structure that enables the serpent to easily manipulate its living prey, without the use of the bodily coils. A number of snakes thus swallow their prey alive, without resorting to constriction or other means of overpowering it.

Though the snakes are largely carnivorous, the methods of hunting and overpowering the prey differ widely among the members of the various families and genera.

Part I.—Methods of Feeding

Snakes practice various methods in killing their prey, but these widely different habits are displayed as unvarying characteristics among the members of genera and families. In some families, such as the cosmopolitan *Colubridae* with its several subfamilies, there exists every method of subduing the prey that is to be noted among snakes. Among the members of other families, the manipulation of the freshly captured prey is usually of a respectively unvarying character. Such families may represent the older types or those of marked specialization. Accordingly, from the viewpoint of their feeding habits, the serpents may be crudely divided into several fairly well-defined groups, but owing to the variability of habits that exists within occasional families, these groups are constructed merely in systematizing the present article, not in accordance with zoological classification.

The suggested groups may be outlined as follows:

NON-VENOMOUS

Constricting species: Serpents of all sizes that kill their prey by coiling about it and squeezing it to death. Members of the *Boidae* and *Colubridae*.

Semi-Constrictors: Species that swallow the living prey, but subdue it by holding within a single coil or pressing it firmly against the ground by a fold of the body while deglutition

proceeds. Typical representatives are Colubrine snakes, *Spilotes, Zamenis* and allied genera.

Non-Constrictors: Serpents that swallow the living prey without effort to subdue it by bodily manipulation. A great number of such species are characterized by their possession of enlarged posterior teeth to permit a firmer hold of the quarry. Members of numerous Colubrine genera: *Tropidonotus, Eutaenia* and *Heterodon* are typical in the exhibition of this habit.

VENOMOUS

Among the poisonous snakes, we consider three types, viz.: the members of the *Opisthoglypha* and the *Proteroglypha* of the *Colubridae,* and the long-fanged members of the *Viperidae.* Two well-defined methods of killing the prey may be noted:

a. The snake seizes the quarry and by a gripping movement of the jaws imbeds the fangs. The bitten animal is thus held until dead, when deglutition begins. A few species are constrictors, but possess little bodily power. These habits are typical of the venomous *Colubridae, viz.,* the members of the subfamilies, *Homalopsinae, Dipsadomorphinae, Hydrophiinae* and *Elapinae.* The shorter-fanged members of the *Viperidae* feed in similar fashion, particularly those species that feed upon birds, lizards or batrachians.

b. Serpents that stab their prey and immediately release it, awaiting its rapid death by poisoning. This habit appears to be confined to the long-fanged members of the *Viperidae.* Typical genera are *Crotalus* and *Bitis.* While this is an almost invariable habit among captive examples of the genera, it must also be understood that such reptiles are excessively nervous and their feeding when wild—particularly in the treatment of smaller prey—may be similar to group "*a*".

By this summary we may note the characteristic feeding traits of serpents. Considering these from the standpoint of zoological arrangement of families, we observe little of significance as regards classification, except among the highly specialized forms which have acquired their remarkable venom-conducting teeth and deadly poison. In the process of evolution away from the lacertilian form, the snakes have acquired, with the elongation of their limbless bodies, a characteristic which appears to be unique among the *Ophidia,* when applied to the killing of the prey. This is constriction, a power which the writer has noted among lizards, but apparently put to no specific use. When handled, the worm-like lizards of the *Amphisbænidae*

FIG. 78. SCARLET SNAKE, *Cemophora coccinea*
A degenerating type of the constricting serpent. Inhabits the Southern United States

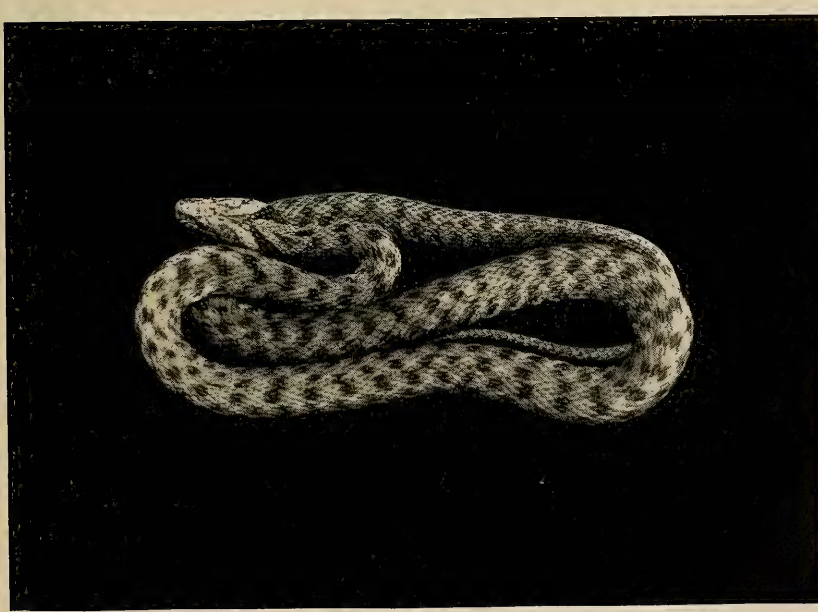


FIG. 79. WATER SNAKE, *Tropidonotus tessellatus*
The manipulation of the prey is by the jaws only. Snakes of this kind lack the power of constriction. Inhabits Europe

exhibit power of constriction, and this is also to be noted among the crude and lowly serpents of ancient lineage, such as the *Typhlopidae* and *Glauconiidae*, but as all of these creatures are mainly insectivorous the power seems of no practical value. Constriction, as an efficient and unvarying method of killing the prey has apparently originated among the members of the *Boidae*, the ancient lineage of which serpents is evident by the presence of rudimentary hind limbs. During the process of specialization it has been retained by many members of the *Colubridae*, particularly those that feed upon warm blooded prey, and curiously enough a strong indication of it here and there appears among highly specialized forms, with well developed fangs. Intermediate traits have already been noted among the Colubrine semi-constrictors and those species which swallow the prey alive.

It is of interest in continuing this preliminary *resume* to note the relationship of food to the methods of feeding. The following table will concisely outline such observations:

NON-VENOMOUS

*Constrictors**: Series *a*. Species that feed only upon warm-blooded prey—mammals and birds. The greater number of the species of the *Boidae*. Many genera of the *Colubridae*—of which the members of *Coluber* are typical examples.

Series *b*. Species that feed upon warm and cold-blooded prey. These snakes devour mammals, birds and other reptiles, though few or none feed upon batrachians. Members of the *Boidae* and *Colubridae*.

Semi-Constrictors: Omni-carnivorous serpents feeding largely upon mammals and birds, but also reptiles and batrachians. Principally Colubrine snakes.

Non-Constrictors: The great majority of these species devour cold-blooded creatures—other reptiles, batrachians, fishes and insects. A large number of Colubrine genera come under

*The greater percentage of the food of constricting species consists of warm-blooded animals.

this head, also the members of insectivorous families, the *Typhlopidae* and *Glauconiidae*.

VENOMOUS

This group embraces several types of feeders, thus:

a. Species that retain their hold after biting.	Fish eaters.	*Homalopsinae*
	Lizard eaters.	*Dipsadormorphinae*
	Lizard & bird eaters.	"
	Omni-carnivorous.	"
	Fish only.	*Hydrophiinae*
	Mammals	*Elapinae*
	Cannibalistic	"
	Omni-carnivorous	"
b. Species that "strike" and release the prey.	Omni-carnivorous	*Viperidae*
	The highly specialized, long-fanged members of the *Viperidae* appear to feed largely upon mammals and birds.	

After an outline of the feeding habits of serpents, it is well to review the more characteristic traits, means of hunting and stalking the prey, and the economic importance of certain species.

While the diminutive Worm Snake (*Glauconia*) of the South American tropics lies in a great ant-hill, where its burnished scalation protects it from the bites of the insects as it feeds upon their larvæ, the huge Boa or the Anaconda, lurks in the jungle growth along river banks on the watch for a passing peccary, capybara or agouti. When the prey is within reach, the neck is drawn into an S-shaped loop, preparatory to striking. It is the habit of these big snakes to lurk near the runways of various mammals, that they may thus capture them on their way to water or in passing from one feeding ground to another. The snake relies upon grasping the animal as it passes within striking distance. It is not unusual, however, if the ill-fated creature wanders by out of the striking zone, for the serpent to pursue. The movements of even the largest constrictors when stalking their prey are remarkably quick and stealthy. Such movements are seldom or never displayed by the big snakes unless prompted

FIG. 80. INDIAN RAT SNAKE, *Zamenis mucosus*
A semi-constrictor. The prey is held down by a loop of the body during deglutition

by appetite. With the prey within striking distance, there is a lunge of the head, the long recurved teeth take firm hold and the reptile's body is literally hurled about the victim, until it is covered with the constricting coils. The process of enveloping the quarry with the powerful folds is wonderfully dextrous among the large serpents. It exceeds in speed that of the smaller, colubrine serpents, which are proportionately more active in pursuit. In the feeding of a twenty-foot *Python reticulatus* involving a vigorous forty-pound pig, the writer noted on several occasions, with a stop watch, that the time consumed from the initial "strike" of the serpent's head, through the dashing of the coils about it and the beginning of actual constriction, to be within two seconds. The snake apparently aims to seize the animal anywhere and the dash to constrict it is to save the reptile injury. Death usually takes place within a minute's time, but during the animal's struggles the reptile, not infrequently, is severely bitten; though the only heed to the injury is to constrict more vigorously or bring another coil to bear. The writer has observed many of the smaller constricting snakes badly bitten by rats, and has examined freshly-caught specimens with severe scars.

The habits described in the preceding paragraph are generally typical of the *constricting* serpents. Their actions in subduing the prey are as characteristic as the injection of a deadly virus by serpents with fangs. Between the constrictors and the poisonous snakes, lie the groups of less pronounced feeding habits. The types we have called the semi-constrictors endeavor to subdue the struggles of the prey, by pressing the animal against the ground with a fold of the body while deglutition is proceeding. Snakes of this type feed upon comparatively small prey. Many of them are rodent-eaters; all are swift of gait and hunt openly, and when seizing small creatures possessing sharp teeth that might be used in vigorous defense, the reptile displays extreme caution in manipulating the animal with its jaws so as to place it at a disadvantage. By a lateral, pulling movement of the jawbones, these snakes endeavor to overpower their prey in the same fashion as the constrictors, by literally squeezing it to death.

Among those innocuous snakes which have been designated as non-constrictors, we note several characteristics in feeding, which point to radiating phases of specialization. The writer endeavors to point out these characteristics owing to the feeding habits of serpents being of particular interest in possibly tracing their develop-

ment and relationship. It is understood that snakes subsist upon prey of great proportionate size, power and in possession of liberal means of defence. Yet these limbless reptiles, aside from the constricting habits of some and the poison-injecting teeth of others, depend absolutely upon the manipulation of the jawbones in the handling, possibly subjugation of the proportionately heavy quarry. Constriction was apparently the oldest type of subjugation, but changes in the dentition among various groups, influenced by the extension of distribution and change of food, brought about new methods of killing the object of food. Among the non-venomous members of the *Colubridae* that indicate no inclination to constrict, the structure of the teeth is in direct relationship to the habits. Thus the frog and fish-eating species have enlarged posterior teeth to quickly pierce and firmly grip the struggling victim. Snakes of this type evince an unique habit against the defensive actions of frogs and toads in greatly puffing up their bodies to prevent being swallowed. With repeated grippings of the enlarged posterior teeth, the serpent pierces the victim's air cavities thus frustrating and overpowering it. With these snakes the dilatability of the swallowing structure and the agility of deglutition are markedly developed. The cosmopolitan genus *Tropidonotus* (Water Snakes) and the American genus *Eutænia* (Striped Snakes) exhibit uniformly typical species of the habits described. With the North American "Adders," (*Heterodon*), we observe greater development of the dentition in utilization of these traits. In the upper jaw is a pair of posterior fang-like teeth that exhibit faint traces of an anterior groove when microscopically examined. Such development may point to the future elaboration of these greatly enlarged teeth into grooved, venom-conducting fangs, of similar structure to those of the *Opisthoglypha*. Similar grooved teeth are to be noted among other Colubrine snakes, apparent with some to a very faint degree.

Among the non-constricting Colubrine serpents the egg-eating D*asypeltis scabra*, of Africa, stands as another type of radiating specialization in the manipulation of the food. Here, a weak-bodied creature is able to swallow an egg three times the diameter of the thickest part of the reptile's body. The jaws have become almost destitute of teeth, but the presence of a few posteriorly situated ones, provide the power for the jaw bones to alternately grip and engulf the food, assisted by peristaltic movements of the muscles of the

neck. The development of the vertebrae in this species into knife-like points extending into the æsophagus to cut the egg shell as it passes, is quite unique among snakes. The regurgitation of the shell afterward, as far as the writer can note, is an absolutely unique trait among serpents. Though many of them feed largely upon eggs, the shells of which are crushed in the throat by the reptile forcing that portion of the body against the ground, the fragments of the egg-shell are swallowed and entirely dissolved by the gastric juices.

In considering the relationship of dentition to the feeding traits of non-venomous serpents it is of interest to note that among the typical constrictors there is but little generic individuality in the structure of the teeth. With snakes that feed largely upon warm-blooded prey, there is a uniform, liberal provision of strong, recurved teeth. Among those that feed principally upon mammals and birds there is a tendency for the anterior teeth to be the longer and stouter. With snakes that seize a struggling creature to kill it by pressure of the coiling body, this development will be seen to be highly efficacious, although quite unsuited to the non-constrictor, which must entirely manipulate the struggling prey by the work of the jaws alone. The dentition of the constrictor is designed to firmly seize the quarry without further movement of the jaws and draw it within the coils to be killed by strangulation. Some generic individuality in dentition, though along the same lines of enlargement of the anterior teeth, exists among constrictors subsisting largely upon birds. The South American and Madagascan Tree Boas, *Corallus*, are good examples. The teeth become gradually enlarged anteriorly in both the upper and lower jaws until the extreme anterior pairs might be designated as really fang-like. A structure like this is highly effective in seizing feathered creatures. The long, extremely sharp teeth pierce the abundant covering of the prey and take positive hold. By far the greater number of serpents evincing a tendency to enlargement of the posterior teeth subsist upon cold-blooded animals and are non-constrictors. The writer has recently noted an apparent trait among non-fanged Colubrine snakes that warrants much investigation. This is a certain paralyzing effect of the salivary secretions. The most definite observation related to specimens of South America Tree Snakes—*Aehtulla.*

The subject of dentition brings us to a similar review of the feeding habits of the venomous snakes. Here we note that among

snakes with fangs the habit of constriction disappears. It is noted to a slight extent with the *Opisthoglypha*. Among the *Proteroglypha* there is but an occasional hint of it, while with the highly specialized *Solenoglypha** it is altogether absent.

We will consider the poisonous serpents in the following order:

Two series of the *Colubridae*, thus:

Opisthoglypha: Grooved fangs situated posteriorly.

Proteroglypha: Short, rigid, venom-conducting fangs developed with internal canal and orifice at tip; the fangs situated anteriorly.

Two subfamilies forming the *Viperidae*:

The *Viperinae* and the *Crotalinae*, with greatly enlarged anterior fangs, that are attached to movable bones.

The Opisthoglyph snakes form a series to which comparatively little study has been devoted. While simpler descriptions have tended to place them among the innocuous species, they are provided with a well-developed fang mechanism and a poison highly efficacious in subduing the prey. A considerable number of the species are of insignificant size, consequently possessing almost microscopic fangs. Some species are large enough to be dangerous to man. The anatomy of the poison apparatus is reversed from that of all other types of venomous snakes, the fangs being furrowed or grooved, and situated in the extreme rear of the upper jaw; while the poison glands are contained within the labial, instead of the temporal region. These snakes may have one, or several pairs of fangs. To imbed these venom-conducting teeth, an Opisthoglyph snake must advance the jaws in a series of the familiar "chewing" motions characteristic of serpents. When the fangs are brought into play, the jaws grip hard. This persistent hold enables the poison to flow down the furrow of the tooth and into the wound.

The writer has made careful note of the feeding habits of snakes of this type that have come to the Reptile House. A considerable number of the Opisthoglyphs are of aboreal habits and it is representatives of this kind the writer has induced to feed. Most of our aboreal species preferred lizards. The attack is a deliberate stalk, the neck is doubled into a lateral loop and the serpent strikes with great rapidity, apparently aiming to secure the victim by the head. The jaws are advanced until the fangs are well imbedded and the prey is killed in significantly quick fashion. The venom appears to act upon

*Members of the *Viperidae*—the rattlesnakes, copperhead and moccasin; the Old World vipers.

FIG. 81. SEA SNAKE, *Platurus schistorhynchus*
Venom from a pair of short fangs subdues the prey. The food consists of fish. Snakes of this type abound in the Indian Ocean

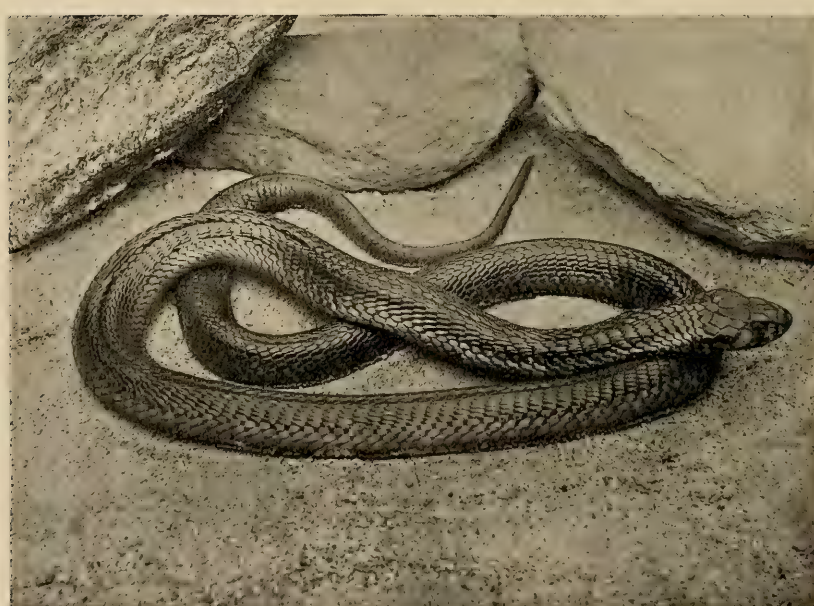


FIG. 82. EGYPTIAN COBRA, *Naja haje*
Short, venom-conducting fangs subdue the prey, which is gripped by the snake's jaws until dead

the nerves, benumbing the victim. An Opisthoglyph snake will kill a lizard in less time than a Proteroglyph or Viperine serpent of the same bulk. From one to two minutes may be consumed in rendering a lizard of the size of the common *Anolis* entirely inert. The writer's observations relate to the South American Tree Snake, *Oxybelis acuminatus,* the Indo-Malayan Green Tree Snake, *Dryophis mycterizans,* the American species of *Himantodes* and the European *Tarbophis vivax.* All of the Opisthoglyph snakes retain their hold of the prey until it is dead, then begin to swallow it without releasing the hold.

With the *Proteroglypha,** a series of the *Colubridae* containing two subfamilies, we observe feeding habits quite similar to those of the representatives of the *Opisthoglypha,* in the retention of hold upon the bitten prey. The present reptiles, however, possess a far more perfect and highly specialized venom apparatus. During the process of evolution into these fanged types, the poison-conducting teeth, primarily grooved, have so folded about the grooves that a transverse section of them shows a well-enclosed internal canal. The poison glands are located in the temporal region, where the masseter muscles in closing the jaws compress these reservoirs, forcing the venom forward and out of the fangs. The secretion is strongly neurotoxic. The members of the *Hydrophiinae,* are altogether aquatic; in fact marine. They feed principally upon fish, and their powerful venom quickly renders the prey inert. They frequently attack species with long and sharp spines, but the poison so relaxes the muscles of the fins that the snake has no difficulty in swallowing the prey. It is worked about in the jaws until the snout points down the reptile's throat, when actual deglutition begins and the spine-bearing fins are pressed against the body of the creature to be swallowed.

The remaining subfamily of the *Proteroglypha* is the *Elapinae,* the cobras, kraits, coral snakes and their allies. The greater number of these are strictly terrestrial and the majority are alert and active in hunting their food. From extensive studies of these snakes, the writer has observed a series of feeding manoeuvres uniformly similar to those of the non-constrictors of the innocuous *Colubridae.* The

*A series of the Colubrine serpents. The members have short, permanently erect venom-conducting teeth situated in the anterior part of the upper jaw. The cobras are familiar Old World species. The coral snakes are New World representatives.

Opisthoglyph snakes with their crude, grooved fangs, and the many highly specialized long-fanged vipers, which we will presently consider, have a marked habit as if strongly appreciative of the deadliness of their fangs, in seizing the prey, firmly imbedding the venom conducting teeth and awaiting without further move, the death of the quarry. Many members of the *Elapinae*, to the contrary seize the prey, imbed the fangs in a series of chewing motions and commence to swallow it at once. In a large number of cases the prey struggles violently and the snake endeavors to subdue it by various movements of the body, even by partial constriction. The short fangs of these serpents are liable to discharge their venom into the pelage or feathers of a bitten animal, which, during the entire process of deglutition may be quite unaffected by the snake's poison. If the prey consists of another snake, a lizard or batrachian, creatures with comparatively unprotected bodies, the fangs are easily imbedded. The effect of the venom upon cold-blooded prey, however, appears not so rapid as that of the Opisthoglyphs. A great number of the elapine snakes feed upon mammals and birds. In a general summary of their feeding habits, the writer would designate the more highly specialized venom apparatus as compared to that of the Opisthoglyphs, as but slightly more efficient in subduing the prey than that of the members of the latter series. It is possible that the elapine snakes form a group in a state of rapid transition toward the development of larger fangs.

The *Viperidae* embraces the most highly specialized serpents, owing to the extreme development of the poison apparatus. With these serpents the elongate and horizontal maxillary bones existing among other snakes, have been reduced to small, vertical, *movable* anterior processes each bearing an enormously elongated fang, with a perfectly enclosed canal and venom ejecting orifice at the needle-like tip. Here the length of the fang is so great that the movable maxillary bones enable these great teeth to be folded back when the jaws are closed. In consequence it is not surprising to find among such reptiles an unique feeding habit adapted to the fang development. This consists of a wonderfully dexterous stabbing of the prey by these terrible weapons, and its immediate release. The bitten animal is able to stagger but a short distance, when it is overcome; it may drop in immediate convulsions. Small animals are often vitally stabbed and instant death occurs from the fang thrust alone. Such are the habits of the larger mammal-eating vipers in attacking

FIG. 83. CAPE VIPER, *Causaus rhombeatus.* AFRICA
Possessing short, poison-conducting fangs, this snake usually grips the prey in its jaws until the venon takes affect

FIG. 84. GABOON VIPER, *Bitis gabonica.* AFRICA
Owing to the enormously elongated fangs, snakes of this development stab the prey by a biting blow from these teeth, and instantly release the jaws

prey, which, if held by the jaws might inflict damage in the death struggles by teeth or claws. Some of the vipers, particularly those which feed upon birds, lizards and batrachians, retain their hold after striking, driving the long fangs deeply into the victim.

The writer has endeavored to definitely note by observations of captive specimens and snakes in a wild state, whether or not, as has been alleged, the habit of striking the prey and releasing it is but a nervous and abnormal habit displayed by vipers under observations. At the time of writing he is assured that this is true to a slight extent, but that the habit of simply striking the prey is common with wild snakes. Two observations in the south relate to definite notes of the feeding of the large Diamond-Back Rattlesnake, *Crotalus adamanteus.* One, a rabbit struck while in the undergrowth, struggled out on a sandy road to die and was followed by the snake, which consumed the rodent; the other, a tame rabbit, bitten while prowling under the foundation of a hut, dashed into a clearing and was later followed by the snake. The writer has noted one observation of a wild Timber Rattlesnake, *Crotalus horridus* and a young chipmunk. In the latter instance the chipmunk ran fully twelve feet before overpowered by the poison and died under a flat stone. Immediately after biting the animal, the snake started leisurely in the direction whence it ran and located the quarry without difficulty. In contrast to the habit, the writer has observed a wild rattlesnake of rather small size bite and hold a short-tailed mouse.

The writer believes that the viperine snake displays a considerable amount of caution in the treatment of its prey. These excessively nervous snakes are also liable to mislead the observer in tracing normal habits, when the reptiles are studied in captivity. There is little doubt that the jaws retain their hold upon more helpless prey if the snake is feeding in its natural environment. Alert, and always anticipating danger as a captive, the reptile under such conditions strikes and immediately frees the fangs in order to be on the defensive. These theories appear plausible when we note the contrasting habits of the very nervous rattlesnakes (*Crotalus*), and the more phlegmatic moccasin and copperhead snakes (*Ancistrodon*). The former, as captives usually strike all animals offered as food; the latter seize all prey and hold it unless it be of the larger rodent type that is liable to injure the snake. Among a number of rattlesnakes of different species reared in captivity and consequently far less nervous than those caught wild, the tendency was to strike and

release rodents, but retain the hold upon birds. Despite this variance in subjugation of the prey, we have noted with the members of this family, a feeding trait possible only with the development of the present highly perfected fang mechanism.

Part II.—The Food of Serpents

In considering in detail the food of serpents, the writer has placed his observations in the order of classification relating to these reptiles.

The *Typhlopidae* and *Glauconiidae:* These small, lowly and ancient types of serpents are persistently subterraneous and appear to be largely insectivorous. The chitinous coverings of insects are to be found in dissected specimens, and examples are commonly dug from termites' nests, gorged with these insects.

The *Boidae:* The Boas and Pythons, of direct ancient lineage as evidenced by their possession of vestigial hind limbs, feed largely upon mammals and birds, although the big tropical lizards are also preyed upon by some of the species. The Anaconda, *Eunectes murinus,* is by far the largest of the New World serpents, and detailed investigations show the food to consist of wild swine (the peccary), monkeys, the larger rodents and various species of water fowl. Although an aquatic serpent, the anaconda, even in an immature state, does not appear to feed upon fish or amphibians. The various species of South American Boa feed upon the larger rodents and birds. While students of the habits of these big constrictors have alleged that the food is restricted to warm-blooded prey, the investigations of Mr. R. R. Mole, Port-of-Spain, Trinidad, have demonstrated a marked appetite among these snakes for iguanas, tegus and other big lizards. The Society is indebted to Mr. Mole for a large number of the tropical American snakes to be exhibited in the Reptile House and for valuable notes on the habits of various South American reptiles. Herewith annotated are several observations by Mr. Mole:

"I do not know whether you are aware of it, but the great snakes are very fond of lizards. They are more easily digested than mammals and birds. Boa constrictors can rarely resist the temptation of a big tegu, and my Indian pythons (*molurus*) have swallowed many iguanas and one devoured a vigorous four-foot alligator."

In their combats with the more sturdy prey, the big constricting snakes are often badly wounded. Old specimens show numerous scars which often point to once existing wounds that barely escaped vital parts. As evidence of these conditions the writer again quotes a communication from Mr. Mole:

"As you are interested in big anacondas, you may like to know that I have an immense beast now. Although she is not enormous in girth, she is very bony and gaunt, and actually measures (I have taped her), seventeen feet! Her skin hangs loosely upon her, and yet in this condition she weighs 104 pounds. Thin as she is, this snake is impressive. As it is not long from the time when these snakes give birth to young, this may account for her emaciated condition.

"She was captured by the men who captured Big Annie*, and when I first saw this new specimen, I thought they had caught her with a forked stick with a spike in the fork. They solemnly swore that this was not so. Nevertheless, she had a punctured wound about one inch behind the line of the eyes, and almost in the center of the back of the head. I got her into a large tank, and from later indications I was led to believe that she had fed upon an ant-eater. I found an immense claw which I supposed belonged to *Tamandua tetradactyla*. Further examination revealed pieces of hair which made me positive that she had swallowed a large specimen of our ant-eater.

"A few days after this I saw the men who captured her, showed them the claw, and they agreed with me, asserting what I had never thought of—that the Matapel (dog killer), our local name for this ant-eater, had made the wound in the anaconda's head, which I now think quite likely. I annointed this wound with a healing balsam, and the snake now seems tolerably well, although there is a likelihood of the wound breaking out again. I am going to try to feed this snake with rabbits, in the manner prescribed in your book on reptiles. She has one or two superficial wounds about the body, and I am sure the Matapel did not succumb before he had made a terrific fight for life. They are dreadfully strong beasts, and their claws are powerful, long and sharp.

"The other day a dead boa constrictor was brought to me. I think it was larger than Castro. I taped it and it measured eleven feet and seven inches in length, and was thickly built. It seized a

*A nineteen-foot Anaconda on exhibition in the Park.

hunting dog and the dog's owner was so afraid that it would kill the beast, ('it had lapped it up', he said), that he destroyed the snake. It was a wonderful specimen, and I told him that it was worth forty of his wretched curs, such as are used by the peasantry in what they call hunting."

As captives the various species of New World *Boidae* are fairly hardy; the species of *Boa*, *Epicrates* and *Corallus* feeding readily upon rodents and birds, although members of the last-named, arboreal genus prefer birds to other prey. The anaconda does not feed so readily, and when it does, our specimens prefer fowl. There is often great difficulty in inducing freshly-caught, adult examples to feed. While the majority of the New World *Boidae* will feed at any time of the day, we have found those anacondas under observation that were inclined to feed, to be particularly disposed to take their prey at night and a few specimens have been induced to feed only at such times. These habits do not pertain to very young examples of the species, two large litters of which we have studied in rearing. The very young snakes, voracious at all times, appear to prefer birds.

The writer's observations of the Old World *Boidae* are fairly complete, having embraced the following species:

Regal Python, *Python reticulatus*	Malaysia
Indian Python, *Python molurus*	India
Rock Python, *Python sebæ*	Africa
Royal Python, *Python regius*	Africa
Diamond Python, *Python spilotes*	Australia
Carpet Python, *Python variegata*	Australia
Tree Boa, *Corallus madagascariensis*	Madagascar
Sand Boa, *Eryx johnii*	India
Sand Boa, *Eryx conicus*	India

The food of *Python reticulatus* is particularly interesting, as this species attains the greatest length and bulk of any known serpent. About a dozen of these superb reptiles have been under the writer's observation, and while the food of the species may be said to consist of various mammals and birds, there is a marked individuality among captive specimens in the preference of different types of food.

From repeated examinations of the crates of newly arrived specimens of *P. reticulatus*, both at the Park and among the several large animal dealers, the writer is convinced that the big specimens

when in their native environment, feed often upon the Indo-Malayan wild swine. Examination of the excreta in sixty per cent. of a series of about forty specimens investigated showed liberal traces of the bristles of *Sus cristatus*, and in numerous cases the horny coverings of the feet. From several crates enclosing snakes of a length slightly over twenty feet, were taken hoof coverings that were estimated to have been those of wild hogs of at least seventy-five pounds weight. Many captive specimens of this great snake refuse all other food but swine, and examples twenty feet in length, swallow a fifty-pound pig without difficulty. An occasional specimen will refuse all other food but fowl. A sixteen-foot snake of this species, would take at a meal, two eight-pound roosters. These big snakes do best if fed at intervals of ten to twelve days. At intervals like this they feed regularly for five or six months when there is an inclination to fast, this condition being stubbornly continued for three or four months. This fast is evidently an instinctive trait that relates to seasonal conditions in the natural environment. Most tropical snakes evince like habits and the writer has observed that those which are voracious enought to feed steadily throughout the year accumulate excess fats, which so derange the important organs as to cause such reptiles' deaths. It is only during the past three years that we have been making regular schedules of the feeding of our more valuable reptiles, and subjecting them, if they do not seem so inclined, to an annual fast of several months duration. This process has quite reversed our former records of the longevity of a number of captives representing tropical species. The writer is convinced that the impossibility of keeping alive the big tropical vipers for more than a year's time has resulted from feeding during a period when the animal has secreted fatty sustenance to carry it past a period of hibernation or æstivation, as the case may be. In support of this view he cites the results of various post-mortems of apparently over-nourished reptiles, in which an undue fatty condition has brought about marked changes in the liver and attendant organs. This annual fasting period particularly appeals to the boas and pythons, which are of peculiarly delicate organization that responds quickly to changes of temperature and undoubtedly affects the feeding habits of these reptiles during the well-defined seasons in the tropics. It should here be understood that the tendency among all reptiles to secrete fatty nourishment to be utilized in periods of prolonged fast, is by far the most pronounced among the snakes. Among notes at hand, the writer is able to quote

the unbroken fast of a specimen of *Python reticulatus*, that continued through a period of eleven months, and another that covered thirteen months' time. Both of these snakes commenced feeding voluntarily and were strong enough to perfectly assimilate their food. In the prolonged fasting of exceptionally valuable examples, the writer has often resorted to force-feeding. In the compulsory feeding of a python about twenty feet in length the writer kills four medium-sized rabbits, removes the skin, then ties the animals together, the hind legs of one to the neck of another; brown twine being used in this treatment. The snake is taken from the cage and held as straight as possible by eight or ten men, when the rabbits are forced down the reptile's throat for a distance of fully six feet. Several of our big pythons have been fed in this manner for periods of about a year. All were brought to a state of perfect nourishment and commenced feeding voluntarily.

The feeding habits of *P. molurus* are quite similar to its larger Malayan ally; some specimens taking nothing but fowl, others, rodents and small swine. Having noted Mr. Mole's reference to the fondness of pythons for alligators, the writer believes, that as the species of the big snakes are more or less semi-aquatic, they often feed upon the various crocodilians that teem in the regions inhabited by these large constrictors. The African pythons are not so hardy as captives as the Indo-Malayan species.

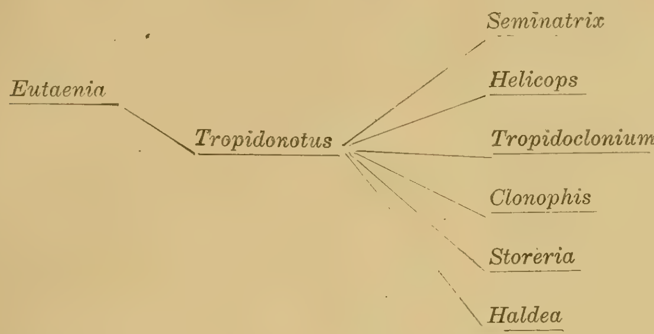
Corallus is a genus of arboreal boas of eccentric distribution, occurring in tropical America and Madagascar. The species prefer birds and are well adapted in seizing the prey by the possession of greatly developed, fang-like anterior teeth in both upper and lower jaws. The small sand boas of India, (*Eryx*), feed upon lizards and small rodents. Among the several small families of apparent relationship to the *Boidae*, the habit of constriction seems common in overpowering small mammals and lacertilians.

The *Colubridae*: The members of this elaborate family feed upon mammals, birds, other reptiles, amphibians, fishes, crustaceans and insects. It is with certain groups of species of this family that we shall consider serpents of economic value to the agriculturist. Passing the first series of the *Colubridae*, the *Aglypha*, all the members possessing solid, recurved teeth, and the subfamily *Acrochordinae*, composed of river snakes living upon fish and small crustaceans, we will consider in detail the subfamily, *Colubrinae*, containing the

FIG. 85. SKULL OF BOA, *Boa constrictor*
There is a tendency for moderate enlargement of the anterior teeth—to be noted with all mammal and bird-eating snakes

FIG. 86. SKULL OF TREE BOA, *Corallus cooki*
The greatly enlarged, anterior teeth appear to assist the reptile in positively grasping feathered prey

typical, non-venomous snakes. The relationship of our first group of genera represented by species under observation, may be simply expressed as follows:



All of the species are viviparous, and subsist altogether upon cold-blooded prey. With the exception of *Storeria* and *Haldea*, the members of these genera are semi-aquatic, although some of the species of *Eutaenia* seldom enter water. However, *Eutaenia* and *Tropidonotus* are closely related, the former possibly an immediate off-shoot of the latter. Hence comparison is of interest.

While the species of *Tropidonotus* quite persistently confine their feeding to amphibians (batrachians), fishes, crustaceans, in fact the creatures of the river banks and marshy places, we note a variance in the diet of those species of *Eutaenia* that have become quite terrestrial and hence removed from a feeding ground generously supplied with amphibians and fishes. These have the habit of preying upon earthworms. The writer has failed to induce any of the North American species of *Tropidonotus* to take such food, nor will the semi-aquatic species of *Eutaenia*, like *E. saurita, sackeni, proxima* or *radix* eat earthworms. The upland forms of *Eutaenia*, however, such as *E. butleri*, *E. sirtalis* and *E. elegans* will feed voraciously upon them. There is no individuality among specimens to be noted here. The variance of habits in *Eutaenia*, as stated, relates strictly to the respective species involved, and is evidently a necessarily acquired trait in a change from the ancestral lurking places.

Feeding generally upon frogs, toads, salamanders and fishes, the species of *Eutaenia* cannot be rated as of economic value. Their depredations among frogs and toads, particularly the latter would,

if anything, place them among those species detrimental to the interests of agriculturalists, although the worm-eating habits of the common *E. sirtalis* should be rated as an economic trait. It is of interest to observe the feeding habits of a representative of the above genus, a specimen of *E. saurita*, noted while in a wild state. The writer witnessed an example feeding in a belt of swampy timber. The high rasping croak of a small frog, directed his attention to the ribbon snake, about two and one-half feet long, which had grasped the frog by a hind leg. So vigorous were the frog's efforts, that it tore itself from the snake's grasp and started away in a series of rapid hops, with the reptile in pursuit. The serpent's movements were amazingly quick, and its power of vision in following the movements of the frog apparently acute. It darted after the amphibian for a distance of possibly eight feet, when the frog stopped, having secreted itself among some leaves. The snake also paused, but was all attention, with neck upraised and constantly darting tongue. It prowled about in frenzied fashion, when a movement of the frog attracted its attention, and it was instantly upon it, this time retaining its hold until the prey was swallowed.

The species of *Tropidonotus* feed upon frogs, toads, salamanders and newts, the larval forms of these batrachians, fish and crustaceans.

The fresh-water snakes are of no economic value to man, and in the vicinity of streams or ponds stocked with game fish, are a menace to the breeding of the same. These snakes are very prolific, the larger species producing litters of from forty to seventy young. The young feed principally upon fish, remaining close to the water, while the older reptiles often prowl the marginal vegetation for frogs and toads. The manner of capturing fish shows a strong adaptation to aquatic life. Prowling along the bottom, the snake watches for prey above it. With the prey in sight, the snake rises and with a snapping, whiplike motion of the neck and head, the jaws widely distended, reaches for the food. It is in this manner that the young snakes enter schools of small fishes. The young reptiles seldom pursue individual specimens. With the food swallowed, the school is again stalked and the manoeuvres continue until the reptile is gorged. These snakes are able to swallow their prey while under the water. A three and a half foot specimen of *T. fasciatus sipedon*, immediately after capture, disgorged eleven "suckers" or mud fish, averaging three to four inches in length, three sunfish, with strong,

FIG. 87. STRIPED SNAKE, *Eutaenia butleri*
Serpents of this kind are of little or no economic value. The food consists largely of batrachians. Inhabits the Central States

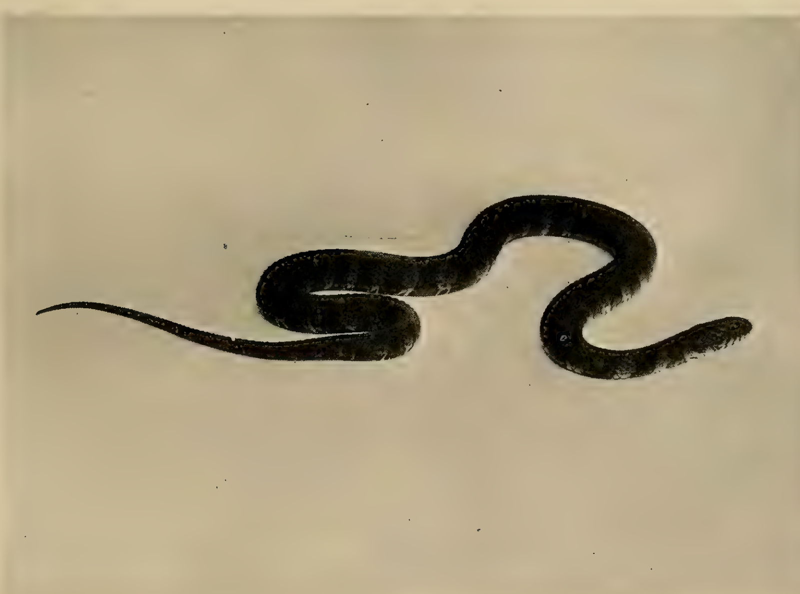


FIG. 88. COMMON WATER SNAKE, *Tropidonotus fasciatus sipedon*
This abundant reptile of the eastern United States is a menace to streams stocked with game fish

dorsal spines, and a crawfish, or fresh-water crustacean of fully four inches in length, with formidable mandibles. Some of the persistently aquatic North American species of *Tropidonotus,* as *T. cyclopium* and *T. taxispilotus* indicate a certain degree of specialization in having the eyes placed further forward and nearer the top of the head denoting better adaptation to life in the water. These species are particularly partial to fish, and a great number of captive examples refuse all other food.

Seminatrix, Helicops, Tropidoclonium, Clonophis, Storeria and *Haldea* are apparently off-shoot genera of *Tropidonotus.* The mode of life has varied and while some are persistently aquatic, others are quite terrestrial. We note among the members of all the genera, the tendency of the development of enlarged posterior teeth to assist these non-constricting types in retaining their hold upon their cold-blooded prey with its comparatively naked integument that is easily pierced by such dentition. The single, North American, species of *Seminatrix,* is apparently a degenerate type of water snake. The strongly keeled scales of *Tropidonotus* are indicated by hair-like lines on a smooth scalation. This snake leads a secretive life near the borders of streams and feeds upon small batrachians. As a captive it refuses fish. *Tropidoclonium* and *Clonophis* are of similar habits. *Storeria* and *Haldea* appear to be of degenerate relationship to the *Tropidonotus* and *Eutaenia* types. The size is small, seldom exceeding twelve inches, and the food consists almost entirely of earthworms. With the South and Central American *Helicops* we see pronounced specialization toward the aquatic type. The eyes are set at an oblique plane with the top of the head, and these serpents prefer fish to any other food.

Passing from the genera just considered, we come into consideration of several genera which fall into a rather crude group. Attending their appearance in technical check lists is a number of other genera which are herewith eliminated owing to their species not having been studied. Those that we will group here are *Zaocys, Zamenis, Salvadora, Phyllorhynchus, Drymobius, Spilotes, Coluber, Herpetodryas* and *Dendrophis.* Among these we find the predominating number of species to be those feeding largely upon warm-blooded prey, some that evince the power of constriction feeding exclusively upon such prey, others to a lesser extent, a few merely indicating this characteristic in their manipulation of the prey or food, and others evincing no trace of the habit. With *Zaocys* of Southeastern

Asia, and *Zamenis*, the latter with twenty-eight species inhabiting the New and the Old world and having among its representatives our familiar black snake, we note the characteristic of semi-constriction. The species are omnivorous as regards the feeding habits of serpents, as they prey upon small mammals, birds, other reptiles (serpents and lizards) and amphibians, although the writer has never been able to induce a serpent of either of these genera to feed upon earthworms.

Zamenis:—Among the species of this genus are several North American snakes that must be rated as of economic value. While they prey to a certain extent upon amphibians, they only occasionally feed upon frogs. They seldom or never attack those amphibians with granular skins, like the toads, and several species of the more terrestrial frogs; hence we might eliminate from their diet, those species of amphibians which are particularly beneficial to the agriculturist. Of slender form, and very active, they hunt for rodents within their burrows, destroying the young and pursuing the adults.

Well-known Old World species of *Zamenis* are the Indian Rat Snakes, *Z. korros* and *Z. mucosus*. Familiar New World types are the Black Snake, *Z. constrictor* and the Whip Snake, *Z. flagelliforme*. Both frequent rather open places, being partial to the edges of meadows where they hunt their prey in the neighboring brush or in stone walls. Here they feed largely upon the smaller rodents, which tend to damage the products of the farmer.

From his studies of the separate species of *Zamenis* in captivity, the writer has noted that the Black Snake evinces a preference for the smaller rodents. It will also eat birds and the various species of smaller snakes, although it does not attack the poisonous snakes as has often been alleged. The writer has noted it feeding upon individuals of its own species, and the closely related whip snake. It will take lizards and is exceedingly active in catching these. Frogs are also eaten, but among these are several species that the snake will grasp and immediately reject. An example of this type of batrachian is *Rana palustris*, which exudes an irritating secretion from the skin. Toads are never eaten, and there is a disinclination to feed upon the tailed batrachians, owing possibly to their irritating skin secretions, although many small snakes feed upon them.

Z. flagelliforme, the Whip Snake, is of rather different feeding habits. It is particularly fond of small rodents and birds, occasion-

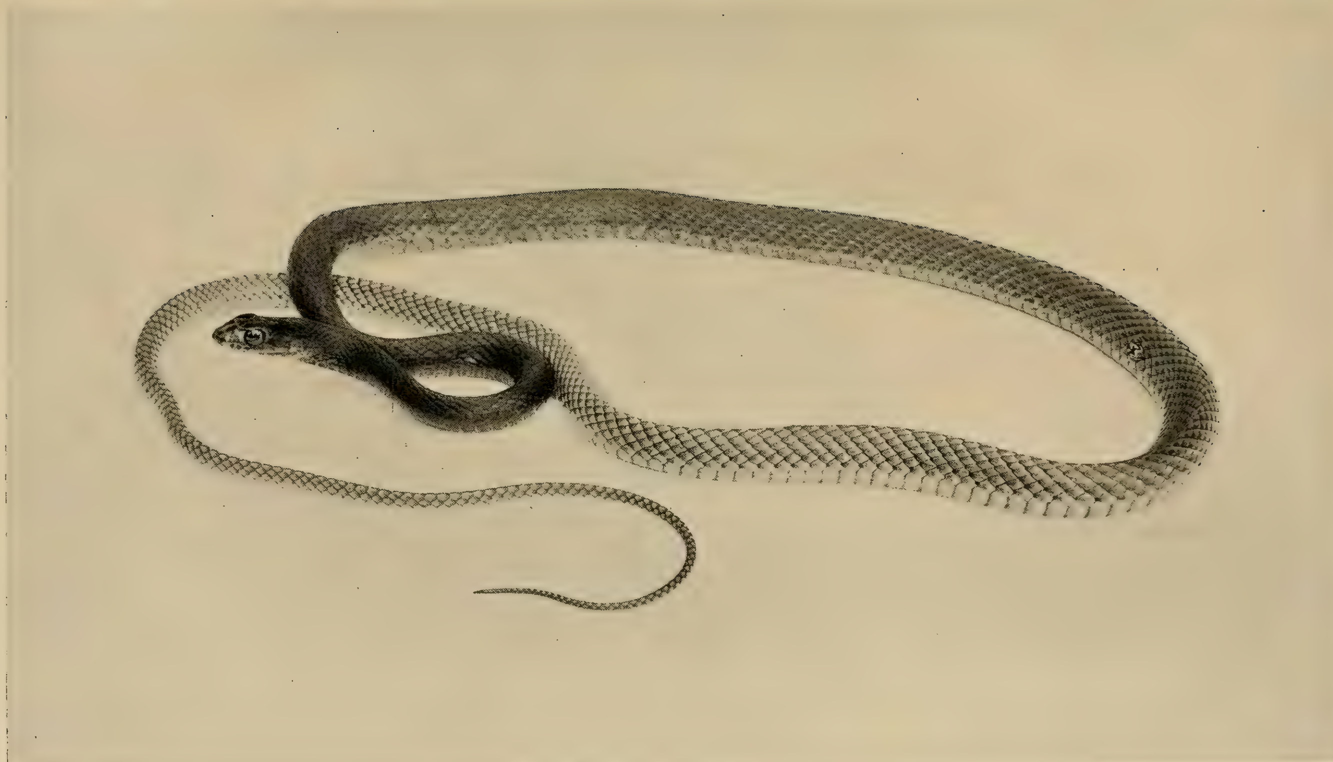


FIG. 89. COACHWHIP SNAKE, *Zamenis flagelliforme*
An economic species of the southeastern United States. The food consists largely of small rodents

ally feeds upon other snakes and lizards, but seldom can be induced to feed upon frogs. These habits relate generally to the different species of *Zaocys* and *Zamenis*, some having a wider range of diet than others, a few feeding almost entirely upon lizards and other small snakes.

Before considering the feeding habits of the other genera mentioned, it is of significance to state that among the species of the subfamily *Colubrinae*, the tendency is for the viviparous species to subsist upon cold-blooded prey, while the great majority of the oviparous species subsist upon warm-blooded animals, or a mixed diet of warm and cold-blooded creatures. All of the species in the present group of genera are oviparous.

Salvadora and *Phyllorhynchus* are apparently off-shoot genera from the *Zamenis* type. Their distribution involves dry and arid regions, and we note the food of *Salvadora* to consist of lizards and small rodents. The feeding habits of *Phyllorhynchus* are practically unknown, but judging from structure, it apparently feeds upon small lizards, other snakes and possibly the young of the smaller rodents. *Drymobius* is a genus of the warmer latitudes and its members feed largely upon batrachians, lizards, and occasionally although not frequently, upon small mammals and young birds. *Spilotes* stands intermediate in relationship between *Zamenis* and *Coluber*, two important genera with a considerable number of apparently related forms. The species of *Spilotes* are particularly interesting in their feeding habits, as they are quite omni-carnivorous—feeding upon lizards and snakes, all types of batrachians, including the toads, which lack of preference in the selection of prey among creatures that greatly vary in a possession of highly irritating skin secretions, is quite unusual for serpents that also prey as often as occasion permits, upon mammals and birds. The species of *Spilotes* must be regarded as of considerable economic value, as mature examples are bold hunters and ever on the alert for rats and mice. Highly active, they feed more frequently than many serpents, and while noting this trait, it is of importance to state that the feeding intervals of various serpents are positively governed by the characteristic activity or inactivity of the reptiles involved. As examples of the inactive type the writer quotes the members of the *Boidae*, which if fed at intervals of twenty days apart will remain well nourished, while serpents of the type represented by *Spilotes*,

Zamenis and the like must be fed at intervals of four to six days, or they soon exhibit emaciation.

The large and important genus *Coluber* made up of New and Old World species, is composed of snakes of considerable economic value. Several important and useful species inhabit the southeastern portion of the United States, where are to be found the Black Coluber, *C. obsoletus*, the Four-Lined Coluber, *C. o. quadrivittatus*, the Gray Coluber, *C. o. confinis*, and the Corn Snakes, *C. guttatus*. All of these snakes feed upon rats and mice, although their food also consists of birds. Their depredations among the birds, however, are quite counterbalanced by their useful work in destroying the small mammals that are a menace to grain and other products of the agriculturist. With the great majority of the species of *Coluber* there is a decided tendency to feed exclusively upon warm-blooded prey. The writer has had under observation a generous proportion of the species of this genus, both the European and American, and in his continuous studies covering a period of over fifteen years, has not induced one of these snakes to feed upon any type of batrachian. Very rarely, these snakes have been noted to feed upon lizards, although they seldom or never exhibit a cannibalistic tendency common among the serpents of the other genera under immediate consideration. Summing up the feeding habits of the genus it is appropriate to describe these powerful constrictors, as snakes of economic importance that feed almost entirely upon mammals and birds. *Pituophis*, an American genus of large and powerful constrictors, embraces quite similar habits, and one species in particular, the Bull Snake, *Pituophis sayi*, is a reptile of such great economic value throughout its habitat, that it might be introduced and protected in the great grain belts of the United States, as a common enemy to the several species of highly destructive ground squirrels or spermophiles.

Of apparent relationship to the genera considered in the preceding paragraph, the writer quotes *Herpetodryas* and *Dendrophis*, that have assumed marked arboreal habits, with a consequent change of food. With *Herpetodryas* we note the interesting trait of a fondness for birds, which are readily captured in the low bushes or trees inhabits, and also a liking for frogs and fish. Several members of this genus apparently waver in the development of their mode of living, between an arboreal life and a semi-aquatic existence. They often dive from the trees into the water in seeking amphibious prey, but the writer has not induced any species of this genus to feed upon

FIG. 90. INDIGO SNAKE, *Spilotes corais couperi*
Found in the southeastern portion of the United States. Of economic importance

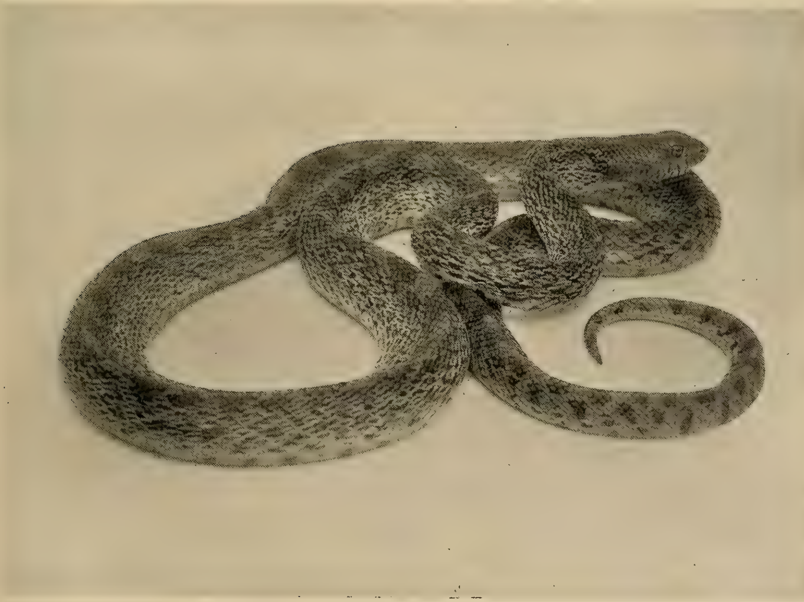


FIG. 91. BULL SNAKE, *Pituophis sayi*
A species of high economic value in the Plains Region of the United States

mammalian prey. *Dendrophis* is a strictly arboreal genus and the food appears to be confined to tree-lizards and such batrachians as can be found among the branches; the food animals of the latter type consist of small species of *Hyla*.

Passing through the maze of Colubrine genera, it is possible to select another group of related forms, a number of representatives of which have been under observation. These are the genera *Coronella*, an Old World genus of six species; *Ophibolus*, the King Snakes of North America, Mexico and Central America (seven species); *Diadophis*, the Ring-Necked Snakes of the United States and Mexico (three species); *Rhinochilus*, the Sharp-nosed Snakes of the United States and Mexico (three species); and *Cemophora*, the Scarlet Snake of the southeastern United States. Close relationship is clearly indicated by well-defined feeding traits. All of the species are proportionately powerful constrictors; and all are oviparous. Without exception, they exhibit cannibalistic habits in feeding upon other serpents and lizards. With the exception of *Diadophis*, which is apparently a degenerate off-shoot of *Ophibolus*, the species of the entire group also feed upon small mammals. A peculiarity of these snakes is their utter lack of interest in the batrachians, the frogs, toads and salamanders, although evincing a marked appetite for cold-blooded prey in the shape of other reptiles. In this habit, the rather insignificant species of *Diadophis* are exceptions as they feed largely upon earthworms and salamanders, although showing relationship to the ancestral group in also feeding upon other small snakes—a rather unusual trait for a very small serpent. One trait of notable specialization away from the parent group as exhibited by *Diadophis* is shown in the retention of the eggs until the embryos are well developed. Thus, with an oviparous species, the young hatch within about thirty days after the eggs are deposited, opposed to the eight or ten weeks required for the incubation of the eggs of the other species involved. As before noted, we may trace among the oviparous or viviparous Colubrine serpents a rather definite indication of preference for warm or cold-blooded prey. This indication is again evident with the present group. *Coronella, Ophibolus, Rhinochilus* and *Cemophora* are composed of species depositing eggs with thread-like embryos and requiring a considerable period for incubation. All of the species feed to a considerable extent upon small mammals. With *Diadophis*, branching from these forms, and restricting the food to cold-blooded creatures, there is the tendency, as

with the strictly viviparous reptile, of retaining the eggs in the oviducts, at least until the embryos are well on their way to development and growth, the formation of the scales and appearance of the coloring pigment.

With the species of *Coronella, Ophibolus, Rhinochilus* and *Cemophora,* we again note an unusual condition among serpents. Although apparently feeding as generally upon other reptiles as upon small mammals, and occasionally birds, they may not be termed omni-carnivorous as they do not feed upon the amphibians. In this respect their feeding habits differ from the members of such well-known genera as *Zamenis* and *Spilotes* which have already been considered. Among the species of the Coronelline genera under discussion there is some diversity of habits as regards the character of the food. With *Coronella* some of the species evince a preference for lizards, while also subsisting upon small mammals; with others the habits are quite reversed. All of the species are more or less cannibalistic. With the New World genus *Ophibolus,* the cannibalistic tendency is particularly marked and carries with it a ferocity that impels the reptile to attack and kill other serpents of a considerably larger size than the aggressor. The *Ophibolus getulus,* common King Snake, feeds largely upon other snakes, attacks and kills the poisonous species and is immune to their bites, unless the fangs pierce an important organ. This immunity is generally indicated among the markedly cannibalistic snakes. The smaller species of *Ophibolus* are cannibalistic, but also feed frequently upon mice and young rats; those inhabiting the southern latitudes varying the diet with lizards. All may be rated as of economic value. The species of *Rhinochilus* are of similar habits. The immediately related and single species of *Cemophora* of the southeastern United States, feeds upon other small snakes, lizards and raids the nests of small rodents to prey upon the young. The writer has noted the habit of this snake of eating the eggs of lizards that are deposited under the loose bark of decaying trees, the species principally preyed upon being *Eumeces quinquelineatus* and *Lygosoma laterale.* A female, *Cemophora coccinea* in the writer's possession displayed the unusual trait of depositing a batch of eggs under a flat stone and a few days later devouring her entire litter.

In a series of Colubrine genera composed of small species, it is of interest to mention the food of the members of *Cyclophis* and *Liopeltis.* These are green, or bronze-green species inhabiting the

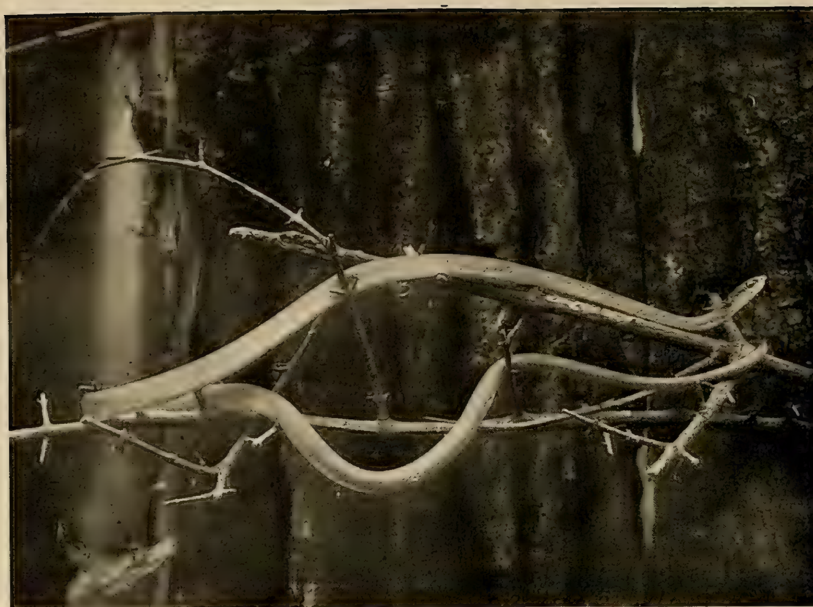


FIG. 92 GREEN SNAKE, *Cyclophis aestivus*
Insectivorous. Few snakes exhibit similar feeding habits

FIG. 93. DE KAY'S SNAKE, *Storeria dekayi*
Unusual in restricting the food to earthworms and the larvae of small beetles

United States and Asia. Two common species, both of a brilliant green, inhabit the United States. The species of these genera are particularly interesting owing to their insectivorous habits. From his observations of small species of snakes and dissections of numerous preserved specimens, the writer is not inclined to believe that many snakes feed upon the imagoes of insects, though it is probable that a number of the very small, secretive species not infrequently devour the larval forms of coleopterous insects. With *Cyclophis* and *Liopeltis*, the species feed generously upon the imagoes of various insects. These snakes are most frequently to be found among low bushes and in vines; but they occasionally prowl in stone piles. They feed upon orthopterous insects, grasshoppers and crickets, and the writer has found the remains of beetles in the stomachs of preserved examples. All of the species are particularly fond of the hairless larvæ of the noctuid and geometrid moths, and a considerable number of dissected specimens showed these reptiles to often feed upon spiders. Long observation has demonstrated, strangely enough, that they will not eat earthworms, the partial food of a great number of the smaller serpents. The species of *Cyclophis* will eat small lizards.

Abastor and *Farancia*, both genera of rather doubtful relationship, though immediately allied to one another, are each composed of a single large and handsome species inhabiting the low coastal region of the southeastern portion of the United States. Both species are burrowers and from their substantial build would appear to subsist upon frogs and toads. Repeated experiments with a great series of adult examples of both species have resulted in inducing these reptiles to partake of but one type of food and under a single, unvarying condition, when these reptiles freely feed. The provision described involves the provision of a shallow tank, well stocked with frog tadpoles. The method of capturing the prey resembles that of the water snakes, although representatives of the species could not be induced to take fish. Very young specimens of *Abastor erythrogrammus* feed upon earthworms, but this food appears to be discontinued when the snake is a few months old. The members of both genera are oviparous; the eggs requiring about eight months for incubation.

Subfamily *Rhaciodontinae:* The single species, *Dasypeltis scabra*, of Africa is characterized by the extreme modification of the teeth which are much reduced in number and the presence of sharp edges of several of the vertebrae extending into the æsophagus. This highly specialized structure is employed in cutting the shells of

the eggs of birds, sometimes of reptiles, upon which the serpent appears to wholly feed. After the covering of an egg is broken the contents are permitted to flow down the serpent's throat, and the fragments of shell afterwards disgorged. This snake appears to be quite unique among members of the entire order in subsisting entirely upon eggs; also in its habit of voluntarily disgorging useless remnants of its food.

The *Opisthoglypha:* The serpents of this division appear to represent the early types of poisonous snakes. Specialization has progressed to a point where venom-injecting teeth are evident, though of a crude type. Their furrowed fangs are of invaluable assistance in subduing the prey and are manipulated with great ingenuity. Owing to the fangs being situated posteriorly, these snakes are unable to strike and thus wound the prey, which is always tenaciously gripped with imbedded fangs and held until it is overcome by the poison. With the different method of feeding, there is a difference in the food as compared with other poisonous Colubrines—the *Proteroglypha.* The great majority of the *Opisthoglypha* feed upon cold-blooded creatures, reptiles, amphibians, fishes and various invertebrates. This is necessarily the case with a great number of species, owing to the very short fangs which would be unable to pierce the pelage or feathers of small mammels or birds, or efficiently inject the poison. The simple fang mechanism of these serpents is primarily intended to be employed in the subjugation of creatures with comparatively naked skins, under which head must be included a favorite food of many of the terrestrial and aboreal species—the lizards—the scales of which are readily pierced by the strong, sharp fangs. With some genera, like the South American *Tomodon,* the fangs are greatly elongated and advanced to a position nearly under the eyes. This dentition would be effective upon small birds and mammals, but unfortunately, the writer has been unable to obtain examples for observation.

The *Homalopsinae:* This subfamily of the *Opisthoglypha* has become specialized in assuming strictly aquatic habits and is thus analagous to the *Hydrophiinae* of the *Proteroglypha* although the members of the latter evince the more extreme specialization along these habits in taking to the sea. With this specialization of habits comes the necessary and characteristic diet of fishes. The members of the *Homalopsinae* feed also upon batrachians, although fishes form the greater part of their diet. Fishes with the fins terminating in

long and sharp spines are a common prey but are swallowed without difficulty as the snake's venom renders the muscles quite inert. The quarry is swallowed head first, the bristling spines folding against the body while deglutition goes on.

The *Dipsadormorphinae:* Despite the elaborate array of species of this subfamily, it is difficult to obtain a representative series of living examples for study. Many of the species are small and secretive; others are arboreal and difficult to capture, and amid these conditions they escape the attention of the collector of living reptiles. A number of living examples of the *Dipsas* type, such as *Tarbophis, Trimorphodon, Lycognathus, Dipsadomorphus, Himantodes* and *Sibon* have been under the writer's observation. All the specimens studied were oviparous and showed a preference for small, soft-scaled lizards and batrachians; usually feeding at night. With *Tarbophis* and *Trimorphodon,* lizards are preferred. The specimens of *Lycognathus, Dipsadomorphus* and *Himantodes* preferred small frogs. Examples of *Tarbophis* and *Lycognathus* were induced to take very young mice and birds, but these were refused if even thinly clad with pelage or feathers. With the strictly arboreal genera, such as *Dryophis* and *Oxybellis* there is an unvarying preference for lizards. No specimen of these latter genera was noted to feed upon batrachians, and but occasional examples exhibited any interest in freshly caught birds or small rodents from the nest.

FOOD OF THE *PROTEROGLYPHA*

While there is marked specialization among the snakes of this series in the possession of venom-conducting teeth, placed anteriorly, and temporal glands for the copious storage of what appears to be the most deadly of the venoms existing among all the known types of poisonous reptiles, the character of the food seems to be analagous to that of the *Aglypha*—the wholly non-venomous Colubrine forms. However, in making up a general average of the species of the *Proteroglypha* observed alive, the number showing a preference for warm-blooded prey is slightly in excess over those feeding upon other reptiles or batrachians. One peculiarity may here be noted. The writer has had under observation no serpent of this series that indicated a tendency to feed exclusively upon warm-blooded prey—a trait already noted among several genera of the *Colubrinae.*

Subfamily *Hydrophiinae:* The food of the reptiles that have taken to a marine life, consists of fish, crustaceans and various other types of salt-water invertebrates. Very few examples that have been observed in captivity have been induced to feed, and small fish were taken. Wild specimens have been noted feeding upon fish which were quickly subdued by the poison. Owing to the roving disposition of these serpents, demanding more activity than displayed by terrestrial snakes, they undoubtedly feed at quite frequent intervals.

Subfamily *Elapinae:* Unlike the subfamilies of the *Aglypha* and *Opisthoglypha,* the genera of the *Elapinae* evince little tendency for arrangement into groups from the standpoint of relationship and well-defined selection of food. At least one genus, however, exhibits food selection of marked interest. This is the single New World genus of the subfamily—*Elaps.* The writer has had abundant living material for study for an extended period of years. All of these snakes are cannibalistic and absolutely restrict the food to other species of snakes and lizards.

Of the *Elapinae* of the Australian fauna, *Pseudechis, Diemenia* and *Brachyaspis* prefer small mammals and birds to other food, although they occasionally eat lizards. None could be coaxed to take batrachians which appeared quite foreign to their diet. Of the African species studied, the Ringhals, *Sepedon haemachates* and three species of *Naja* were of similar habits.

The Indo-Malayan cobras, *Naja tripudians* and *N. bungarus* (King Cobra) exhibit food habits of great contrast. The common cobra feeds ravenously upon small mammals and birds and lives for years in captivity. It will also eat birds' eggs, but instead of breaking the shells in the throat by muscular contraction as is the habit of most colubrine serpents* when thus feeding, the eggs are swallowed entire and the shells left to be broken by the action of the gastric juices, which process is completed in about forty-eight hours. The writer has never observed an example of the Indian Cobra feeding upon either reptiles or batrachians, and it is his belief that this species limits its food to warm-blooded creatures. Compared with the feeding habits of the Indian Cobra, the diet of the King Cobra, *Naja bungarus,* is of particular interest, as this nearly allied, much larger and powerful snake is strictly cannibalistic. It appears never

*A habit commonly displayed by *Coluber, Pituophis* and allied genera.

to feed upon mammals or birds, and of particular significance is the evident restriction of the diet to snakes alone. The writer's specimens have lived for years with various lizards running about their cages, without eliciting the least interest on the part of the Cobra. Moreover, the writer's experiments tend to show that other poisonous snakes are seldom or never eaten. These habits are at variance with other markedly cannibalistic Elapines, as the species of *Elaps* have been noted to kill and eat small rattlesnakes, *Sistrurus*, while they often feed upon the smaller lizards of the *Scincidae* and *Iguanid.ae*

Following are notes involving the feeding of *Naja bungarus:*

To test the assertion that *N. bungarus* feeds but seldom upon the Viperine snakes, possibly possessing an instinctive dread of the deep wounds liable to be inflicted by the fangs of such reptiles, the following experiment was conducted.

A large, thick-bodied, harmless water snake (*Tropidonotus taxispilotus*), and a poisonous water moccasin (*Ancistrcdon piscivorus*), of much the same proportions, were selected for the experiment during a period when the big cobra was voraciously awaiting its weekly meal of a living snake. The door of the cage was rolled back, and the poisonous snake thrown inside. The cobra made the customary rush for the food, but upon reaching the snake paused abruptly.

This was the first time in the feeding of this king cobra in our Reptile House that he failed to immediately seize his victim and begin to swallow it. The moccasin was permitted to remain in the cage for about five minutes, during which time the cobra reared slightly from the door, and regarded it intently. To ascertain whether the cobra was hungry, a common striped snake was placed in the cage. It was grasped and swallowed without hesitation.

The moccasin was again introduced. There was the same rush, and the same careful examination of the newcomer. This time, annoyed by the unceremonious treatment it had received, the pit-viper showed fight. Upon this display of hostility the cobra backed off hurriedly, nervously dilating its hood, and rearing upward. The moccasin was finally removed unharmed, and the large, harmless water snake was quietly placed in the cage. To the human observer it matched the moccasin closely, and made a show of temper considerably more emphatic than the former, but the cobra attacked it without an instant's hesitation and soon swallowed it. This experi-

ment was repeated, and always with the same result. The cobra appeared to instantly distinguish the dangerous character of the poisonous snake.

Of all species of snakes under the writer's observation, the king cobra is the most intelligent. Its actions indicate quick reasoning. A slight movement at the door of its cage will bring it rushing to the opening, where it prowls about, nosing and inserting its tongue along the frame, in the anticipation of food. This snake has been frequently observed, as the feeding period was approaching, to assume the graceful attitude of its kind—head and neck upraised to the level of the small plate-glass window in the door of its cage—and follow intently, with turning head, the movements of the keepers in the passage behind the cages.

In serpents, such actions are unusual. They appeal more to mental faculties exhibited by mammals. In numerous other instances the writer and his keepers have noted the unusual intelligence of king cobras. Their apparent sagacity, together with the possession of fangs, and probably the most virulent poison of all snakes demands the greatest caution on the part of those who maintain a collection of living specimens. While feeding, the king cobra not only displays considerable cunning, but also great agility. When a snake is placed in the cage, the cobra dashes upon it, seizes it by the middle of the body, and within a few seconds' time the fangs have done their work. Snakes, however, are rather slow to succumb to the venom of these reptiles. On the part of the victim there is vigorous opposition to being thus treated. The cobra is repeatedly bitten, but it regards with stoical indifference the superficial wounds inflicted by the teeth of its prey, and continues working the body of the snake along in its jaws with the idea of reaching the head, which portion is swallowed first. Sometimes the quarry is seized near the head, and in such cases it soon disappears down the cobra's throat. Frequently however, the cobra has some trouble in working its jaws toward the victim's head. At such times the larger reptile pauses often, and awaits an opportunity of seizing the other by the neck. If the attacked snake makes a movement to bite the cobra on head or neck, there is a counter movement of great rapidity. The body is released and the approaching head is seized with astonishing quickness, after which performance the engulfing process begins without more ado.

The fine representative of this species in the Reptile House has no aversion to taking snakes that have been freshly killed. Its good-

nature permits economy to be practiced, for in times of scarcity each snake offered is first killed and stuffed to its full capacity with frogs or rats, and thus it is made to equal in bulk and nourishment a half dozen snakes of equal length not treated in this manner.

Several examples of *Naja*, representing *N. bungarus*, *N. tripudians* and the African *N. haje* have been received at the Reptile House, where examination showed they had been deprived of their fangs by native snake charmers. After such mutilation few poisonous snakes can be induced to feed. Reptiles in th's condition have been kept alive and in vigorous condition, however, by force-feeding them with beaten eggs poured down the throat through a glass funnel after the snake has been grasped by the neck and the body held upright.

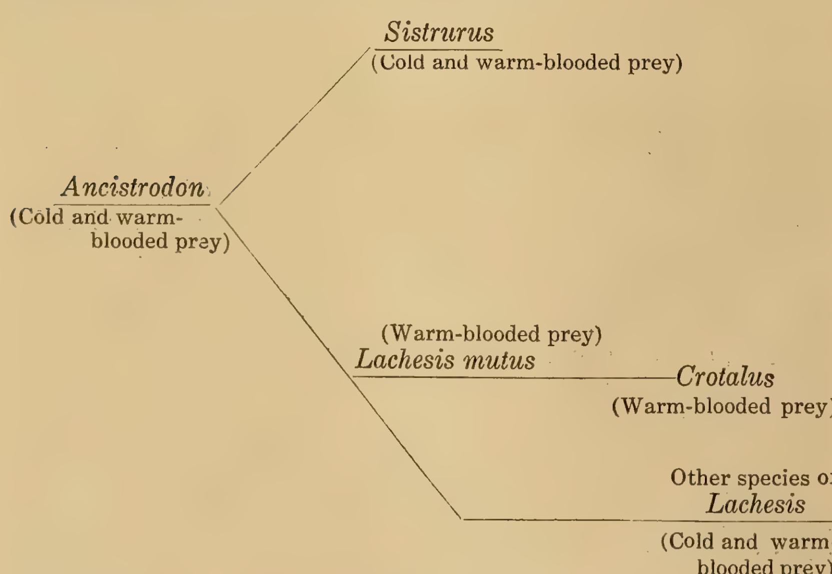
The food of *Elaps*, the only New World genus of the Elapine serpents has already been noted to consist entirely of other snakes and lizards. The method of feeding is similar to that of the king cobra, though these smaller snakes dipslay less ingenuity in overpowering their prey. It is quickly grasped and worked along in the jaws until the head points down the throat, when swallowing commences. Upon cold-blooded prey the poison is slow in taking effect; and, although the fangs may be observed to be repeatedly and vigorously employed, the subtle fluid appears to aid the snake but little in subduing the quarry, which generally struggles energetically during the entire swallowing process.

These snakes will consume serpents of surprising dimensions in proportion to their own length and thickness of body. The writer has observed the Harlequin Snake (*E. fulvius*) swallowing snakes that were but a few inches shorter than the feeding reptile, and of greater circumference of body. After completing a meal of such proportions, the gorged snake is rendered so rigid of body that it is unable to coil properly, and the skin is so greatly distended that the scales appear as well-separated rows of dots.

All of the species evince a liking for lizards, and especially the smooth-scaled species of the Family *Scincidae*. Numerous captive examples of the Harlequin Snake have fed upon the blue-tailed lizard (*Eumeces quinquelineatus*), while specimens of the large South American Coral Snake (*E. corallinus*) have taken adult specimens of the red-headed lizard (*Eumeces quinquelineatus erythrocephalus*) fully nine inches in length, and of stout proportions. The lizards show much more susceptibility to the action of the poison than snakes.

The writer has had no opportunity to study living examples of the *Amblycephalidae.* Systematic observations may reveal interesting traits among these snakes, characterized by the small gape and limited dilatability of the swallowing mechanism. Apparently connecting the *Colubridae* with the *Viperidae,* their methods of feeding and the kind of food selected are characters which should be noted together with their alleged relationship.

The Viperine Snakes: Among these, the most highly specialized forms of reptile life we find what appear to be indications of well-defined food selection following the trend of specializa on. Although there is an immediate relationship between New and Old World species of the *Crotalinae,* the writer believes there should be generic distinction between the New and Old World species of *Ancistrodon* and *Lachesis.* He bases this opinion upon preliminary studies of his friend Dr. Joseph E. Tompson, who explains that the hemipenial characters of the species of the Eastern Hemisphere are markedly different from the New World Crotaline snakes under the same generic rating. From the standpoint of relationship and food the New World *Crotalinae* may be thus defined:



The species of *Ancistrodon,* apparently representing an older type of development, possess relatively short fangs. Unlike the more

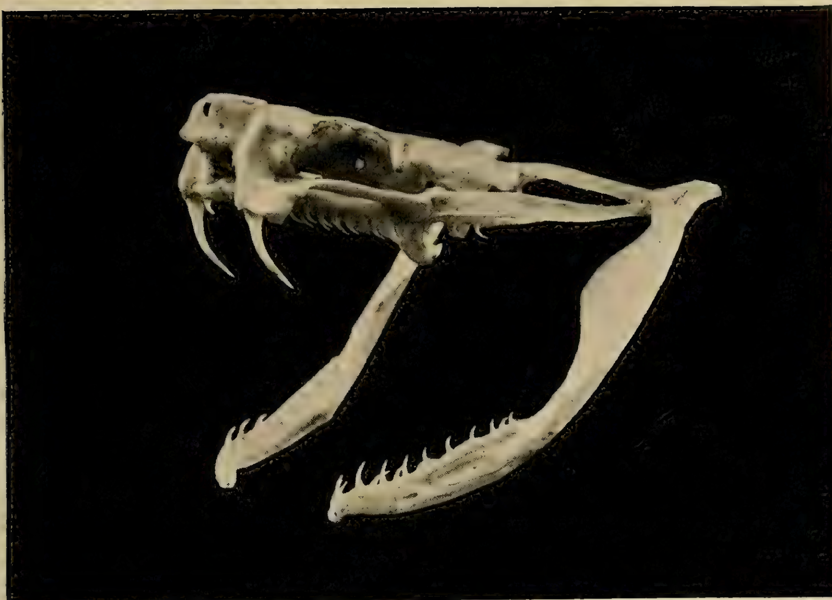


FIG. 94. SKULL OF MOCCASIN, *Ancistrodon piscivorus*
The dentition points to the earlier types of Crotaline snakes

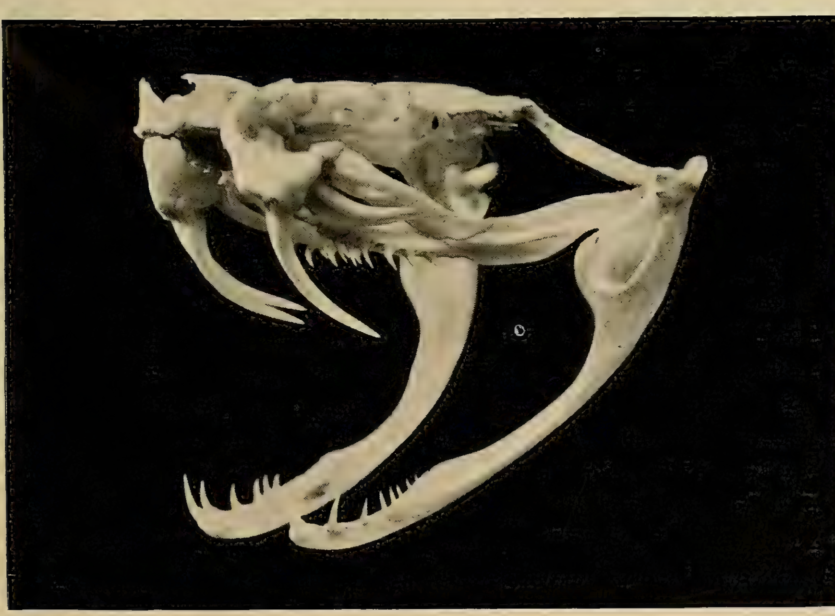


FIG. 95. SKULL OF BUSHMASTER, *Lachesis mutus*
Extreme specialization in fang-development is to be noted

highly specialized Viperine snakes, they seize their prey and retain the hold until its death. All of them are *omni-carnivorous*, feeding upon mammals, birds, reptiles, batrachians and fish. The writer has observed none of the species—not even very young examples of any—to show interest in earthworms or like food; the food appears to be quite restricted to forms of vertebrate life, the latter a condition noted with all the observed species of the *Viperidae*. This broad range of food renders *Ancistrodon* characteristic among all viperine serpents. The food habits of *Sistrurus* appear significant when compared with structural characters similar to *Ancistrodon*. The writer believes *Sistrurus* to be a direct offshoot of *Ancistrodon* and on an independent branch of development from the larger and more highly specialized rattlesnakes, *Crotalus*. The species of *Sistrurus* feed as readily upon frogs as they do upon small mammals and birds. A peculiar trait is the disposition to retain the hold upon cold-blooded prey while they strike warm-blooded creatures. We thus note two habits in their feeding—that of the more primitive long-fanged snake and of the highly specialized type. The same feeding habits are to be noted among the New World species of *Lachesis*—except *L. mutus*. Snakes of the *L. lanceolatus, alternatus* and *neuwiedii* type feed upon mammals, birds and batrachians, and are inclined when nervous, to merely strike the warm-blooded food while the cold-blooded prey is seized and held until dead or swallowed while it is alive. *Lachesis mutus* is an exception. The writer is not at all convinced as to the correctness of including this unique form under the same generic heading of the snakes formerly grouped under *Trigonocephalus*. Its source of origin has apparently branched abruptly away from that group and represents the origin of *Crotalus*, with the immediately related South American *C. durissus* and the geographical extension and elaboration of species toward and into North America. From repeated examinations of the intestinal contents of examples of *Lachesis mutus*, it seems to feed altogether upon warm-blooded prey. Adult captive examples cannot be induced to take food; Mr. R. R. Mole, of Port-of-Spain induced a young example to take mice. With the reasonable certainty that this fine reptile, by far the largest of all *Crotaline* serpents confines its food to warm-blooded prey, we have a habit rendering it unique among the species of the genus it stands as a member. These feeding habits also tally with those of *Crotalus*; no example of any of the species of which has been noted by the writer to feed upon other than warm-blooded prey. The writer's notes on

the genus *Crotalus* cover observations on living representatives of twelve species.

In the Old World, the *Ancistrodon* type has survived in the shape of puny terrestrial forms, while the *Lachesis* (*Trimeresurus*) types have become an extensive branch of mostly arboreal forms; among all of them we find the food selection to cover cold-blooded prey as well as small mammals and birds.

The *Viperinae:* It is not apparent that this present subfamily of the *Viperinae,* originating along a source involving the *Crotalinae,* but represents a parallel type of development from a near source. In lesser specialized forms, like *Causus,* appealing to the *Colubridae* in scalation of the head and quite remarkable in being oviparous, we note an arbitrary habit as compared with the later forms in the food selection of cold-blooded prey, although these snakes also feed upon small mammals. Among the smaller species of *Vipera,* with the larger head shields such as *V. berus,* there is a tendency to feed upon lizards besides small mammals. Coming to the highly specialized forms like *Bitis* and *Atheris,* we note the same positive restriction of food to warm-blooded prey as described to exist among the later Crotalines.

As a comparative review of the food selection of serpents, the writer has prepared a table that follows and which includes only those species under thorough observation and represented by a generous number of examples. The term *omni-carnivorous* is used to concisely designate those species which feed upon both warm and cold-blooded prey. Species of pronounced economic value are marked.*

CHARACTER OF FOOD**

	Warm-blooded	*Cold-blooded*	*Invertebrates*
FAMILY *GLAUCONIIDAE*			
Glauconia albifrons			Insectivorous
FAMILY *BOIDAE*			
Subfamily *Pythoninae*			
Python reticulatus ‡	Mammals and birds		
" *molurus* ‡	"	Large Lizards	
" *sebæ* †	"		
" *regius* †	"		

**See reference notes at end of schedule.

FIG. 96. FER-DE-LANCE, *Lachesis atrox*
Typifying a comparatively late development among the snakes. The fangs are much elongated. Such reptiles are intensely nervous as captives. They usually refuse to feed

	Warm-blooded	*Cold-blooded*	*Invertebrates*
Python spilotes †	Mammals and birds		
" *variegatus* †	"		
Subfamily *Boinae*			
Epicrates cenchris †	"		
" *angulifer* †	"		
" *striatus*†	"		
Corallus madagascariensis	"		
" *cookii* ††	"		
" *hortulanum* ††...	"		
Eunectes murinus†	"		
" *notæus*†	"		
Boa constrictor†	"	Large Lizards	
" *imperator*†	"	"	
" *mexicanus*†	"	"	
" *madagascariensis*†...	"	"	
Ery conicus†††	"	Lizards	
" *johnii*†††	"	"	
" *jaculus*†††	"	"	
Charina bottæ†††	Small mammals	"	
FAMILY *COLUBRIDAE*			
Subfamily *Colubrinae*			
Eutaenia sackenii		Batrachians;§ fishes	
" *saurita*		"	
" *proxima*		"	
" *radix*		"	Earthworms
" *butleri*		"	"
" *sirtalis*		"	"
" *elegans*		"	"
" *e. infernalis* ...		"	"
" " *marciana*		"	"
" " *vagrans*		"	"
Tropidonotus leberis		"	
" *grahami* ...		"	
" *fasciatus* ...		"	Crustaceans
" " *sipedon*		"	"
" *rhombifer* ..		"	"
" *cyclopium* ..		"	"
" *taxispilotus*.		"	"
" *natrix*		"	Earthworms
" *tessellatus* ..		"	
Seminatrix pygæa		Salamanders	
Helicops angulatus		Batrachians; fishes	
Tropidoclonium lineatum.		"	
Clonophis kirtlandi		"	
Storeria dekayi			Earthworms
" *occipitomaculata*.			"

	Warm-blooded	*Cold-blooded*	*Invertebrates*
Haldea striatula			Earthworms
*Zaocys carinatus**	*Omni-*	*carnivorous*	
*Zamenis constrictor**	“	“	
“ *flagelliformis**	“	“	
“ *tæniatus**	“	“	
“ *mucosus**	“	“	
“ *florulentus*	“	“	
“ *diadema*	“	“	
Salvadora grahamiæ	“	“	
Drymobius margaritiferus	“	“	
*Spilotes corais**	“	“	
“ *variabilis*	“	“	
*Coluber guttatus**	Mammals and birds	§§	
“ *subocularis**	“		
“ *quatuorlineatus**	“		
“ *vulpinus**	“		
“ *obsoletus**	“		
*Pituophis melanoleucus**	“		
“ *sayi**	“		
“ *catenifer**	“		
Leptophis liocerus		Batrachians	
Dromicus angulifer		“	Insectivorous
Heterodon platyrhinus		toads; frogs	
“ *simus*		“	
“ *nasicus*		“	
Coronella austriaca	*Omni-*	*carnivorous*	
Rhinochilus lecontii	“	“	
“ *antonii*	“	“	
Cemophora coccinea	“	“	
Virginia valeriæ			Earthworms
“ *elegans*			“
Abastor erythrogrammus		Batrachians	“
Farancia abacura		“	“
Carphophis amœnus			Earthworms (Insectivorous)
Subfamily *Dipsadormorphinae*			
Tarbophis fallax		Principally lizards	
Trimorphodon lyrophanes		“	
Himantodes cenchoa		Lizards; Batrachians	
Leptodira annulata		“	
Dryophis prasinus		Principally lizards	
“ *myclerizans*		“	
Oxybelis acuminatus		“	

	Warm-blooded	*Cold-blooded*	*Invertebratas*
Subfamily *Elapinae*			
Pseudechis porphyriacus.	Mammals and birds		
Denisonia superba.......	“		
Brachyaspis curta.......	“		
Naia haie...............	“		
“ *flava*.............	“		
“ *melanoleuca*.......	“		
“ *tripudians*.........	“		
“ *bungarus*..........		Strictly cannibalistic	
Sepedon hæmachates.....	Mammals and birds		
Elaps corallinus.........		Snakes and lizards	
“ *fulvius*...........		“	
“ *marcgravii*........		“	
“ *lemniscatus*......		“	
FAMILY *VIPERIDAE*			
Subfamily *Viperinae*			
Causus rhombeatus......	Small mammals	Lizards	
Vipera berus............	Mammals and birds	“	
“ *aspis*............	“		
“ *ammodytes*.......	“		
“ *russellii*........	“	(Young feed on batrachians)	
Bitis arietans...........	“		
“ *gabonica*..........	“		
“ *nasicornis*.........	“		
Cerastes cornutus.......	Mammals		
“ *vipera*..........	“		
Subfamily *Crotalinae*			
Ancistrodon piscivorus..	*Omni-*	*carnivorous*	
“ *contortrix*...	“	“	
Lachesis mutus.........	Never induced to mammals in wild	feed in captivity, state.)§§§	but known to take
“ *lanceolatus*.....	*Omni-*	*carnivorous*	
“ *atrox*..........	“	“	
“ *pictus*.........	“	“	
“ *neuwiedii*......	“	“	
“ *schlegelii*.......	“	“	
Sisturus miliarius.......	“	“	
“ *catenatus*.......	“	“	
Crotalus terrificus §§§§...	Mammals and birds		
“ *confluentus*.....	“		
“ *durissus*........	“		
“ *horridus*........	“		
“ *tigris*..........	“		

	Warm-blooded	*Cold-blooded*	*Invertebrates*
Crotalus mitchelli	Mammals and birds		
" *lepidus*	"		
" *cerastes*	"		

NOTES:

‡In captivity these species take swine, large rodents and poultry.

†Prefer large rodents (principally rabbits), chickens and pigeons.

††As captives, take sparrows, young pigeons and young rats.

†††Captive examples are fed upon sparrows and mice.

§Frogs, toads, tadpoles, salamanders and various small fresh water fish.

§§Mice and rats; sparrows. Particularly hardy in captivity.

§§§Mature captive examples have never been induced to take food. The only feeding note concerning a captive specimen comes from Mr. R. R. Mole, of Port-of-Spain. A young example under his observation took mice.

§§§§Captive rattlesnakes prefer rodents and small birds. The smaller species in the New York Zoological Park are fed mice, young rats and sparrows. Such species as *C. adamanteus* and *C. atrox* are given young rabbits and cavies.

While reptiles have received their full share of technical attention, very little practical work has been done relating to investigations of their economic importance. The preceding summary of species studied alive will point out a considerable number that may well merit the field observations of the planter and general agriculturist. Members of such genera as *Zamenis, Coluber, Pituophis* and *Ophibolus* may be regarded as of marked economic value in the vast grain belts of the United States and their introduction into localities infested with the smaller sciurine rodents is well worth serious trial and extended observation. The species of *Pituophis* should be particularly useful owing to their strictly terrestrial habits and inclination to prowl into the burrows of small mammals. With a liberal number of snakes introduced into a rodent infested territory, investigations of the reptiles' food is comparatively easy by the killing of a moderate number and the examination of the stomach contents. These observations should be carefully conducted during the rearing season of mammalian pests to determine to what extent the reptiles prey upon the young in the nest. If inclined to follow such habits they must be rated of high economic importance. While a number of the omni-carnivorous Colubrine species feed upon birds, their depredations among these in a region abounding with rodents would be small as they would naturally select the more easily captured prey. As captives the greater number of such snakes are voraciously fond of rodents—particularly of the young.

Feeding Traits of Serpents

Various curious feeding traits exist among serpents, which may be characteristic of individual species or of all the members of a genus. The reluctance of some species to feed at all as captives has already been described. This particularly relates to species of the *Viperidae.* Exceptions to this habit are found among the species of *Ancistrodon* which readily feed, even under adverse conditions. A general habit among all serpents is the abrupt and entire cessation of feeding with the female as pregnancy develops. This relates to both oviparous and viviparous species. With the former, there is a shorter period of fasting, this lasting about four weeks. With the viviparous species there is a period of positive fasting, varying among serpents of different groups from six to eight weeks. Theoretically it would appear that excess nourishment would be needed during the period of the development of the young, but exceptions to this rule, which feed occasionally up to the deposit of eggs or birth of the litter, are rare. The period of gestation among the viviparous *Colubridae* is about eighteen weeks; among the *Viperidae* it appears to be about twenty weeks. With the *Boidae,* gestation seems to require a longer period. The writer has usually noted the viviparous members of the *Boidae* to commence their fast three months before the appearance of the young. Oviparous species that have been received while containing eggs, never fed until the eggs were deposited.

In the assimilation of its food, the snake, if in healthy condition, wholly dissolves the bones, and usually the teeth. Strangely enough, the claws of a mammal do not appear to be generally attacked by the reptile's gastric juices. The pelage of a mammal is little affected by these juices, and masses of it when dried and separated from the excreta so retain the color and lustre as to render identification possible.

During the action of digestion on the great mass of unlacerated prey, decomposition with its attendant gases, is rapid, and the stomach of the reptile becomes greatly distended until the gastric juices break through the body walls of the engulfed animal. Poisonous snakes appear to more quickly assimilate prey dying from their venoms than if it be killed in other ways.

A great number of serpents can be induced to take freshly killed animals. With most specimens of this type it is necessary to move dead animals in order to attract the snake's attention. The

power of scent combined with the mysterious, yet all important, nerve-permeated tongue, are important requisites in locating the food while the reptile is in a wild state.

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NOTES ON

No. 12. THE ONTOGENY OF THE WHITE IBIS

By

C. WILLIAM BEEBE

No. 13. SPECIALIZATION OF TAIL DOWN IN DUCKS

By

C. WILLIAM BEEBE, AND L. S. CRANDALL

No. 14. EFFECT OF POSTPONED MOULT IN CERTAIN PASSERINE BIRDS

By

C. WILLIAM BEEBE

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Fig. 97. PLUMAGES OF THE WHITE IBIS.

A, Downy Chick; B, Head of downy chick; C, Juvenile plumage; D, Post-juvenile plumage; E, Head of adult male in the breeding season.

Volume 1. Number 12.

NOTES ON THE ONTOGENY OF THE WHITE IBIS, *GUARA ALBA*

By C. William Beebe, *Curator of Birds.*

Part I—Breeding Habits.

As soon as the White Ibises are placed outdoors in the large flying cage, in the spring of the year, the breeding pairs spend much of their time in the small tree in which they have nested for the past two seasons. Usually one of the two nests has survived the winter's storms and shows at least a solid basal platform of twigs. There seems to be little definite courtship in these captive birds, and I am quite certain that they remain paired throughout the year. There is much quarreling over the nests, but as for two seasons in succession the same sites have been chosen, there is little doubt that each pair occupies the same nest or nesting site.

At first the males remain in the vicinity of the tree more than the females, and indeed, for many days before actual building commences the males will spend almost the entire day, standing on the old nest or a nearby branch, one leg drawn up, but watchful and ready with raised wings, open beak and inflated chin pouch to frighten away any other birds intruding on their territory.

The sexes share equally in bringing material for the nest, although the actual interlacing of twigs seems to be the duty of the female. At least I have seldom seen the male do more than awkwardly fiddle about with a twig which he had brought, while upon the arrival of his mate he stepped out upon a branch and allowed her to attend to the actual building.

I have never known when the first egg was deposited and not until the full set is laid is there any abstract hint of eggs in the nest, and this only from the continual setting of the birds. Both take part in incubation, and during different times in the day I have seen the male as often as the female on the eggs. It is not uncommon for the male to bring fish to his mate, but I

have not observed a reverse case of feeding. The eggs are laid in June, usually about the first week, and the time of incubation lies between twenty and twenty-three days. Both parents take part in feeding the young. The comminuted fish is brought in the gular sac which is developed in both sexes. The male, owing to the enlargement of the chin sac, is able to pack much more into his throat than his mate. When one of the old birds comes to the nest with food, the bill is opened widely and the young Ibis reaches up and takes the food from the throat of the parent. The sight of this feeding process is contagious and I have seen unmated ibises moved to fly up with offerings of food, and even the young bird of the preceding year makes similar attempts. All are hustled away by the parents, however, before they have had even a chance to carry out their altruistic efforts.

II. Development and Annual Changes.

For several years one or two pairs of White Ibis, *Guara alba* (Linnæus), have bred in the flying cage of the New York Zoological Park. Usually two eggs are deposited but only a single bird in each brood is reared to maturity. In 1912, a young Ibis was hatched on July 6th, and another in a second nest, about a month later. The desire to have this species established as a regular annual breeder in the Park has led me to leave the birds almost wholly undisturbed, but it was found possible during the present year to make a number of new observations, and the necessary handling of the nestling did not interfere with the faithful care of the parents, who were able successfully to rear the young bird.

No definite description of the sequence of plumages in the White Ibis has ever been written, as far as I have been able to discover, and knowledge of the time of attainment of the fully adult plumage is equally vague. In many ways Audubon's account is not reliable.

The nestling in down plumage reveals a number of interesting characters. At the time of hatching, the pterylosis of the bird shows a very advanced development of down on the anterior portions. Thus the head, neck, upper breast and anti-

brachium or fore-arm are covered with a dense growth of down, jet black on the crown where it is sleek and velvety, but becoming somewhat longer and of a brownish, smoky hue on the neck and wings. The remainder of the body is at first almost bare and later only thinly clad with straggling, woolly down, smoky gray on the dorsal surface and white on the under parts. It would seem as if the young bird was prepared for protection from the cold only on the head and neck, somewhat as in the emperor penguin, in which these portions project from the dermal pouch of the parents.

The crown down consists of a spray of 10 or 12 spine-like barbs, of equal length (about 6 mm.), furnished with simple barbules along their basal half. A down feather from the back has usually a greater number of barbs, considerably longer (15 mm.), whitish at the base, shading into smoky gray, very soft and pliable and clothed almost to the tip with barbules of similar texture. These two types of down characterize the two distinct zones which I have mentioned. The egg-tooth is small but very sharp, white and fixed on a dusky rectangular base which is shed about the third day. The wing claws are small, with sharp, recurved tips and are present on the first and second digits. The legs and feet are large and strong. All the visible skin of the body and the anterior aspect of the tarsus is of a dull leaden hue, the posterior tarsus and the feet being flesh colored. The curious changes in the flesh colors of the face and bill and the iris I will describe separately.

Although at the time of hatching the down of the head and neck is more advanced than that of the body in general, yet the changes which take place during the ensuing two or three weeks reverse this condition. The contour feathers of the body and wings sprout at once while the head and neck remain as at birth. During the third week when the sheaths have begun to dry up and the juvenile plumage becomes recognizable, the young bird becomes restless and now and then climbs out of the nest and along the nearby branches. When a month old, if frightened it will fall or scramble to the ground, but when this happens in the flying cage the young Ibis is not able to return in spite of its excellent climbing powers, but must be replaced by the keeper.

In the southern White Ibis rookeries, scores of young birds at this stage are to be seen scampering about in flocks on the ground, long before they can fly.

About the sixth week the young bird begins to use its wings and in a few days can accompany its parents in search of food during the day, returning with them to roost on or near the nest at night. Even at this time there is little change in the nestling plumage of the neck, but when the flight feathers have reached their full development, most of the neck down has been shed. The last trace of this nestling down is found on the crown, where it remains as a conspicuous spot of dense velvety black, many days after the bird is in full juvenile dress. This mark may be distinguished a long distance off.

In this juvenile plumage the head and neck are streaked. The feathers are gray or ashy white with darker brown centers. This dark marking is most pronounced on the head and upper neck, narrowing and paling on the throat and lower neck, and dying out in the form of shaft streaks on the breast. The ventral plumage from the breast backward, the lower back, sides, rump, tail-coverts, the basal half of the tail and the under surface of the wings are pure white. The entire wing, mantle, scapulars and terminal half of the tail are olive brown, most of the feathers with an oily green gloss, changing to copper. The concealed portion of nearly all these feathers is more or less white.

We thus see that except for the smoky gray down of the upper part of the body being replaced with white, the general arrangement of color in the nestling and in the juvenile plumage is similar.

Except for a steady increase in size and the gradual loss of the velvety down cap, no further change takes place during the first summer and autumn, but late in the winter, usually about February, a moult begins, starting on the mantle and scapulars, and spreading outward over the wings and posteriorly to the tail. This moult is not a short, well defined one but proceeds slowly throughout the year both in wild and in captive birds. In the second summer, the bird is usually quite white, retaining only the old primary and tail-feathers and those of

the head and neck. These become exceedingly worn, frayed and faded to a sandy brown. The two former are shed at the regular season for moulting of the species, but not until October or November of the second year is the plumage of the head and neck renewed, that of the crown persisting, as before, until all the other feathers are shed. In the spring the gular pouch begins to be developed in the males and the scarlet breeding pigment appears, and the bird is ready to breed in fully adult plumage in the third summer of its life, when two years old.

The changes in the White Ibis, in the color and pattern of the fleshy parts, eyes and bill during growth are of interest. In the downy chick the irides are hazel, the bill short and straight. The most common type of bill coloring during the first week of life is where it is crossed by five zones of color, two median bands of pinkish flesh, bounded by three equally broad areas of black, the most distal at the very tip of the beak, the second across the center and the third occupying the entire basal area, except for a narrow white frontal line in front of the eyes and extending longitudinally along the margin of the feathered area. There are also two small gular patches of pink and the skin of the chin, between the mandibles, is of the same color. The culmen of the three-day chick measures about 19 mm., the lower mandible being several millimetres shorter. This inequality in length, curiously enough, is reflected in the terminal band of pigment, which extends considerably farther toward the base than the corresponding dark area on the tip of the upper mandible.

A good deal of variation is observable in a series of chicks but the five-banded beak is characteristic. The next commonest type is where all but the distal band of black is absent.

In the chicks hatched in captivity the white loral spots disappear before the end of the second week. This transient character is of interest as perhaps representing the permanent facial marking of the related Glossy Ibis (*Plegadis autumnalis*).

On the sixteenth day, July 29th, the increase in the length of the bill was about 12 per cent. On the thirty-fifth day the basal part of the bill had become entirely black, with the exception of the distal band of pink which persisted conspicuously.

The two gular patches had increased in size and intensity of color.

On the fifty-sixth day the pale band had disappeared from the lower mandible, but was still discernable on the upper. A new area of pale color had now appeared at the tip of the upper mandible.

About a month later, when the young bird was eighty-three days old, the pale terminal area on both mandibles had spread backward, so that the anterior half of the beak was then a clouded pinkish. The basal half was not as black as in the young chick. Ten days later the pinkish area had reached the second of the congenital pale zones, and the skin around the eye had become distinctly pink.

In the six months' old bird the bill was wholly of a clouded pink color, very much lighter than in the adults. The bare face was pale flesh color. The iris at this age was pale slate blue, with a narrow inner ring of hazel.

Recorded measurements in millimetres are as follows:

	Length.	Culmen.	Wing.	Tail.	Tarsus.
3-day chick	150	19	29		22
23-day chick	230	37	60	23	55
2-months' juvenile	450	65	235	90	75
18-months' bird	625	158	286	100	92
Fully adult bird	675	168	290	106	100

I have kept a record of the pigment producing possibilities of the feathers of a young growing White Ibis. The feathers of the juvenile tail are uniform only in that the terminal half is brown, and the basal half white. The zone of darker color is not constant, and in the twelve feathers of any individual no two may be alike, while the white area may be immaculate, or variously clouded or mottled, especially on the outer web, with brown pigment. A feather may appear, which on the terminal half, is solid brown on the inner, broader web, while the outer is pure white, the line of demarcation here being the shaft, but this is exceptional. Having in mind that it is upon such variations in feathers that the theory of color-change in the dead feather has been chiefly based, I applied the only possible proof, and by marking feathers such as the last, kept them under con-

tinual observation. The appearance of such asymmetrically pigmented feathers would seem to lend credence to such color-change, but in every case where my clipped and threaded observation feathers were scrutinized, there was no infiltration or even local wearing or change in area of pigmentation whatsoever. The variation in the juvenile feathers of the White Ibis is congenital, not transitory or ontogenetic.

If feathers be plucked out from the wings of a two months' old bird, the new growths which take their place differ little or not at all from the original ones. In the third and fourth months, however, much of the immature brown pigment is lost, and from the sixth month onward the ingrowing feathers will be pure white as in the adult. Normally these would not appear for another six or eight months. In the five months' old bird one can readily detect every vicious peck it has received from other inmates of the cage, by the white feather or group of feathers which marks the place of the others plucked out.

In early spring, if one of the dull brownish outer primaries be pulled out, there comes in a feather, not pure white, but with the pigment strengthened and concentrated on the terminal half and very strongly glossed with iridescent green. This is identical with what I found occurring in the intensified melanism zones in wild doves. [1]

Nothing definite seems to have been recorded in regard to the annual change in color of the exposed soft parts of the adult White Ibis. In mid-winter, the bill and face of the bird is of a rich fleshy pink, evenly colored throughout. About Christmas or the first of the year the first change is noticeable, which, rather remarkably, is a paling of the color. The region about the eye, the lores and the base of the bill for some 15 mm. from the base, fades from pink, to pale pinkish white. The face and the basal band on the bill, about mid-February, again increases in color and gradually becomes intensified. The legs and feet show no change but the cheeks, with their white feathering, begin to be puffed out. A month later, well into March, the most interesting change is a dark ring which appears around the middle of the beak about 75 mm. from the tip and spreads in both

[1] Zoologica, Vol. I. No. 1, p. 31.

directions. This darkens and clouds the pink but does not wholly obscure it. The legs now begin to brighten.

In April the face and basal portion of the beak are scarlet, and the chin swelling very large. The black, in some individuals, reaches the tip of the beak, in others remains as a very wide band, occupying the middle third of the mandibles. The first of June sees the height of nuptial development (Fig. 97, E). The pure white birds show face and mandibles, legs and feet of richest scarlet, the bill paling anteriorly and tipped or banded with dusky. The cheeks protrude, the bluish white eyes stand out in strong contrast against the surrounding scarlet. The skin of the chin is produced into an inflatable sac which at moments of intense excitement protrudes like a rounded scarlet bladder. After the eggs are laid, the coloring diminishes and the chin pouch becomes reduced about half, or at least is seldom swelled out to full size. The paling of the red in the mandible throws the dark area into stronger contrast for a time, when it too loses strength and fades. The females are less brilliant and almost lack the chin swelling.

For the notes on changes in the color of the beak of the young Ibis I am indebted to Mr. Crandall, and for the loan of skins to Dr. Dwight and Mr. Chapman.

FIG. 98. TAIL-FEATHERS OF DUCKS.

A, Juvenile central rectrice of Wood Duck with down attached; B and C, Juvenile tail-feathers of Torrent Duck with down attached; D, idem, with down recently lost; E, Post-juvenile tail-feathers of Torrent Duck.

Volume 1. Number 13.

SPECIALIZATION OF TAIL DOWN IN CERTAIN DUCKS

By C. William Beebe, *Curator of Birds, and*
L. S. Crandall, *Assistant Curator.*

The careful examination of the birds which are constantly added to the collection of the New York Zoological Park is made for a two-fold purpose. First, of ascertaining their physical condition, freedom from disease and their general health, and second, to obtain data in regard to the characters revealed by the living bird, especially as to the plumage; its moult, structure, pattern and color in continuance of the experiments which have been conducted in the Department of Birds in the past. Unexpected and interesting conditions are occasionally observed, worthy of record, but not dealing directly with the evolutionary problems which the Curator at present has under consideration.

On examining several chicks of the American Wood Duck, *Aix sponsa* (Linnæus) hatched in the Zoological Park on July 12, 1912, it was noted that the down or plumaceous feathers representing the rectrices at birth, were remarkably stiff and long in comparison to the other feathers of this plumage. The left central rectrice down was measured and found to be 29 mm. in length. Careful watch was kept of a young bird selected for experiment but it was not until July 22, the tenth day after hatching, that an increase in length was noted. On this day, the feather mentioned above had reached a length of 32.5 mm. It soon became evident that this gain in length was due to the pushing out of the rectrices of the juvenile plumage, carrying the plumaceous down on their tips. This left central rectrice, together with its burden of down, was measured carefully every other day for a period of a week, the growth being as follows:

July 12—29.0 mm. One day chick.
July 22—32.5 mm.
July 23—35.3 mm.
July 25—40.9 mm.
July 27—46.2 mm.
July 29—51.5 mm. Seventeen day chick.

The average daily growth of the feather through the later period is thus shown to have been 2.8 mm. The feather continued to grow at approximately the same rate until August 7th, when the distal down portion was lost. The right central rectrice, to which the down was still attached (Fig. 98, A), on this day measured 74.5 mm. By August 12th, all but two of the remaining tips—the right central and the next to the outer right —had been lost. On August 13th, having persisted for a period of thirty-two days, these last two disappeared, leaving the young bird with the pennaceous juvenile tail feathers remarkably long for an Anserine bird of its age, and with the tips of the feathers not soft and pliable, but exceedingly stiff, the rhachis in each feather showing a reduction in diameter only toward the tip, which was broken squarely off.

Although as has been stated, an increase in the length of the rectrices was noted on the tenth day after hatching, it was not until July 26, four days later, that incipient growth of the under tail-coverts and the feathers of the pectoral tracts was observed. These were the first of the contour feathers to appear, the upper tail-coverts and lower back feathers being delayed for another three days, so that the rectrices had begun their growth a full week before the other important pterylæ of contour feathers. These latter carried the plumaceous feathers on their tips for a very short period, the attachment being extremely weak and they were lost almost at once, as is the case with the majority of birds.

The interesting point about all this, is the impetus in growth of the juvenile rectrices, hinting of some function in early life of which we are still ignorant, and the alteration in structure of the rhachis of the juvenile rectrices, due to the extremely intimate relation which exists between these feathers and the preceding natal down.

In the Ruddy Duck, *Erismatura jamaicensis* (Gmel.), the retention of the caudal down is carried a stage further, the stiffened shafts of the nestling plumage often remaining in place until most of the scanty, soft barbs have worn away. Not until the juvenile rectrices are three-fourths grown, does the down begin to lose its hold and fall. The bare, truncated extremities of the juvenile tail-feathers give the tail, as a whole, an appearance very unlike that of the succeeding moult, where the rectrics, though stiff as those of a woodpecker, yet taper at the tip and end in finely graduated points.

In examining, at the American Museum, a series of Torrent Ducks, *Merganetta columbiana* Des Murs, from Colombia, South America, I was at once struck by the condition of the rectrices in two young males. They were shot on the 25th of September and had attained the full juvenile plumage. In fact, the long scapulars and the tail-feathers already showed considerable wear. The latter were the special point of interest, carrying the specialization of the rectrice down to an extreme, far beyond that in the two stages already described in the Wood and Ruddy Ducks. The general effect was of a stiff-vaned. distal, feather racket connected with the normal part of the rectrice by a considerable extent of strong, bare shaft (Fig. 98, B and C). It seemed impossible at first glance that the stiffened tips had anything in common with the down plumage of other ducks.

The first close examination showed, however, that these peculiar tips were the persistent down plumage, much abraded, but still remaining attached to the full-grown and already considerably worn tail-feathers of the succeeding plumage. Two facts were self evident; first, that in *Merganetta* even in the down plumage, tail-feathers, specialized in the direction of the stiffened adult rectrices are present and must be of considerable use in enabling the young birds to avoid being carried down stream in a rush of water, or in helping them to clamor up slippery, mossy rocks; second, the physical connection between these down feathers and the succeeding juvenile rectrices is so strong that the former persist long after the next plumage is full grown, and during this period are of material benefit in providing greater length and stiffness to the tail-feathers.

In a bird shot about two months later, in mid-November, the tips had disappeared, leaving 2 to 5 mm. of strong, bare, projecting rhachis (Fig. 98, D). Even if there were no distinction of color or pattern between this plumage and that of the adult, the two could be told by a glance at the tail-feathers; those of the younger plumage showing unfinished, broken tips, while in the succeeding rectrices the shafts end in a delicately graduated point, clothed to the very tip with barbs (Fig. 98, E).

The Torrent Ducks are of interest in this respect, as showing that what in other members of the family is merely an evanescent physical connection between two series of feathers, has in this case been carried to a much greater extreme of specialization, probably of direct benefit to the species.

Volume 1. Number 14.

EFFECT OF A POSTPONED MOULT UPON THE SEQUENCE OF PLUMAGE IN CERTAIN PASSERINE BIRDS

By C. WILLIAM BEEBE, *Curator of Birds.*

In 1908 I published in the American Naturalist an account of certain experiments on this subject, and since that time I have had so many requests for excerpts that I have thought it advisable to record the experiments again in full in ZOOLOGICA. As this work is to be renewed and elaborated in the future, easy reference to this preliminary paper is desirable.

One of the best-known phases of bird moult is at the commencement of the season of courtship, when the male of many species assumes a more or less brilliant or specialized plumage and in the autumn sheds it in exchange for a more sombre winter garb, often resembling that of the female. In the United States, striking examples are the Scarlet Tanager, *Piranga erythromelas* Vieillot, and the Bobolink, *Dolichonyx oryzivorus* (Linnæus). In Africa, weaver birds of the genera Vidua and Pyromelana, exhibit radical seasonal changes.

The problem which attracted me was the discovery of the factors which determine this seasonal change. So untouched is this field of research that at first no definite method offered itself; there was no previous line of work to be followed or extended. The most hopeful way of work seemed to be to clear the ground by gradually eliminating all negative factors, to demonstrate those conditions which would inhibit such a plumage change, and thus narrow down to the important dynamic phenomena of physiology or external environment. The thousand and one influences which impinge upon the organism from its environment (using that word in its widest sense), may be grouped under certain heads, all or any of which may be concerned in moult and in sexual plumage, change of color

and pattern. These again may operate directly ontogenetically, or indirectly along phylogenetic lines.

Condition of the bird's body—fat or thin.
Food—amount, and whether vegetable or animal.
Blood pressure—raised or lowered.
Sexual organs—active or inactive.
Inheritance.
Temperature—heat or cold.
Meterological conditions of humidity or aridity.

These are only the most apparent factors, they are of unequal value, and some are almost wholly dependent upon others. They represent what I tentatively selected when I first began these experiments, as a convenient review of the general field.

This experiment concerns only the first of the above factors, the condition of fatness or thinness of the bird's body, and its influence on moult. I do not claim that it has further influence than this. The unexpected result in color change or lack of it, must be concerned with influences, other than immediate, acute, physiological conditions.

After all the stress and cares of the breeding season are past, birds such as tanagers and bobolinks are always thin and in poor condition. The worn and bedraggled feathers reflect the actual physical state. The keel of the breast-bone—that true index of a bird's emaciation or obesity—often protrudes conspicuously beneath the skin. Not until the autumn moult is complete do the birds begin to improve and then they may become unusually fat. These general facts doubtless hold good in the case of most birds.

Fat is one of the most insidious dangers incident upon a collection of living birds. Unlike the condition in mammals there is liitle or no external evidence of increasing obesity, and only when the bird is in the hand and the breast feathers blown aside, are the yellow rolls of adipose tissue visible. In the Zoological Park it is necessary to examine many small birds at frequent intervals to ascertain their condition, and to regulate the proportions of the food ingredients accordingly.

In mid-summer I placed several Scarlet Tanagers and Bobolinks under careful observation. None of these birds had been allowed to breed, and so, although it was rather late in the season, they were still in the height of vocal and physical condition. They were all tame, so that, although during the period of experimentation they were confined in rather small cages, each bird in a space of about 12 x 12 x 24 inches, yet their plumage was not damaged by violent struggles caused by fear or a desire to escape, and remained throughout in almost perfect condition.

Little by little I began to cut off the supply of light and slightly to increase the amount of food. This caused a corresponding decrease in activity on the part of the birds, and an almost immediate increase of weight. The great danger from obesity in caged birds is that fright or sudden excitement of any kind, may cause a blood vessel to break, or in some other way bring about death from apoplexy. Consequently I kept the birds in a room where they were never disturbed, and where the absence of noise and other distractions reduced the possibility of an untimely end.

In about a month, when the time for the normal autumn moult arrived, the tanagers and bobolinks were living the "simple life" in a dim illumination, and although consuming a fair amount of food, were exercising but little. The time for the autumn moult came and passed and not a single feather was shed. The cages were made intentionally of wire mosquito netting, the fine mesh of which would have caught and revealed any feathers had any been moulted. In addition to this, the birds were examined twice a week, and nowhere on body or head was there any evidence of moulted, or of new, incoming feathers. On blowing away the breast feathers the yellow sub-cutaneous layer of fat could be seen, which in a bird caged under normal conditions, would have been a danger symptom not to be disregarded.

As the winter gradually passed, it was evident that the birds had skipped the autumn moult entirely, and appeared to suffer no inconvenience as a result. As far as appearance went they were in perfect health, showing only the symptoms of

inactivity consequent upon an excess of adipose tissue. Early in the experiment the songs of the birds became less frequent and sustained, and finally died away altogether, and when a good layer of fat had accumulated, seldom was even a chirp uttered.

From time to time a bird was brought gradually into a brighter light and meal-worms added to its diet. This invariably resulted in a full resumption of song. Even in the middle of winter a tanager or a bobolink, would, under these conditions make a room ring with its spring notes, and with this was correlated a slight decrease in weight. This phase of the experiment could not be prolonged indefinitely, however, for the song period seemed limited, just as it would be under normal conditions even in non-breeding birds, although the nuptial plumage remained unchanged throughout the winter. As one of my keepers pithily put it, "We have their calendar twisted backward."

A sudden alteration in temperature—either higher or lower—wrought, I found, a radical change in the physical metabolism of the birds. Under such conditions, they would cease feeding almost altogether, and one tanager lost weight rapidly. A few feathers on the neck fell out and in the course of about two weeks this individual moulted every feather and came strongly into his normal winter plumage of olive green. The metabolism set up by the change in temperature, in its extent and rapidity seemed comparable only to the growth of a deer's antlers.

Early in the following spring individual tanagers and bobolinks were gradually brought under normal conditions and into their seasonal activities, with quick result. Just as the wild birds in their winter haunts in South America were at the same time shedding their winter garb and assuming the more brilliant hues of summer, so the birds under my observation also moulted into the colors appropriate to the season. Herein lay the significant fact of the whole experiment: *The old scarlet and black feathers fell from the tanagers and were replaced by others of the same color; and from buff, cream and black, the bobolinks moulted into buff, cream and black!* There was no exception;

the moult was from nuptial to nuptial, not from nuptial to winter plumage. The dull colors of the winter season had been completely suppressed.

We thus have proof that the outward manifestation of the sequence of plumage in these birds is not in any way predestined through inheritance bringing about an unchangeable succession, in the case of the tanager, of scarlet-green, scarlet-green, year after year. The katabolic changes of pigmentation in the blood are induced by certain seasonal factors, whether internal, as the sexual organs, or external, as food or changing meteorological conditions, we know not. But we do know that this orderly succession may be interrupted by certain external conditions in the environmental complex.

The pigmental changes in the blood which induce the green autumn garb, undoubtedly went on as usual in my birds. The one individual which reacted to the change in temperature proved this. But in course of time, although this pigment was not permitted to be expended in its normal feather-impregnation, it was changed by some seasonal alchemy, and the scarlet pigment made ready. When at last I permitted the moult to take place, the bird was clothed in the dress appropriate to the season, and if wild, would have suffered no handicap in the functions for which its brilliance is intended. It is interesting to note that the green plumage which was so completely suppressed, is unquestionably the more ancestral and primitive, as it is the garb of the young of both sexes and of the adult female.

Nature offers us a curious comparison and normal control in the Summer Tanager, *Piranga rubra* (Linnæus), the male of which retains the scarlet plumage throughout the year. So that what I was able to induce by abnormal methods, is the normal sequence in this closely, indeed generically, related species.

Until I have further and more complete data, checked by results derived from control of other factors of the environment, I shall refrain from further comment on the significance of this initial experiment.

There is genuine satisfaction in thus making even the merest beginning at the elucidation of these problems, which in

their general evolutionary aspect are of far wider application than to the class *Aves* alone. And work along these lines is all the more enjoyable because success demands the continual life and good health of the individual birds upon which the experiments are carried out.

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PRELIMINARY PHEASANT STUDIES

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CURATOR OF BIRDS

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Three months of the summer of 1912 were spent by the writer in the museums of London, Tring, Paris, Berlin and other cities, studying the pheasant collections of these institutions. The ultimate use of the data is for inclusion in a Monograph which is under preparation, but a number of the more general results seem worthy of immediate publication.

GENERAL CLASSIFICATION.

Not until my studies of the Pheasants are completed do I feel it desirable to discuss the relationship of these birds to one another in detail. Realizing how artificial and arbitrary have been the previous attempts to find some character which would be of use in separating the major divisions of the family, I made elaborate tabulation of several scores of what seemed characters of significance. These were set down at random as I passed from genus to genus in the course of my researches, and not until the final summing up did I know whether any would prove of taxonomic worth.

A number of them, like the character of the relative length of individual primaries, gave encouragement at first only to be discounted by some wholly unexpected exception. Finally one character alone remained and after careful application to every genus it has been found to present no illogical exceptions, and in its unusual nature to be most suggestive. Before going on to discuss this in greater detail I wish to re-emphasize the method pursued in elucidating this and other taxonomic characters. This was not to lay out specimens of *a priori* supposedly related groups and then examine them for resemblances; but, as I have said, by a blind tabulation of very many characters

observed in one genus after another, the succession of genera decided often by mere accessibility of the drawers in which the skins were kept.

For inclusion in the Monograph I had long ago chosen arbitrarily to begin with *Ithaginis* and passing through the more typical Pheasants and through *Gallus* and *Argusianus*, to include *Pavo*, thus accepting on the whole the latter half of the family *Phasianidae* as defined by R. Bowdler Sharpe.[1] Of the twenty-two genera which he lists I admit nineteen and these I have separated into four sub-families by the *mode of moult of the rectrices*.

From the very first day of my two years' field work among the wild pheasants, I made strenuous efforts to assemble a collection of immature, and of moulting adult birds, rather than the fully feathered adults which comprise most museum collections. In this I was successful in the case of all but two genera and when I came to examine carefully the pheasants in various museums I was surprised to find many in actual moult, although outwardly presenting no hint of this condition. So I had no dearth of material of feral birds and in no case had I to depend upon captive specimens, although where I have been able to examine the latter, the conditions have been found to be identical with those observed in the wild shot pheasants.

Not until I had nearly completed my studies did I come across Dr. Bureau's most interesting works on "l'Age des Perdrix." His eleven years of careful and methodical study of the moults of the European Partridge and his equally careful study of the plumage ontogeny of the Red-legged Partridge shows beyond question how regular and reliable is the developmental and seasonal succession of feathers, and that in this respect it is as valuable and trustworthy a character as the color, pattern or form of any dermal structure. When, by the process of elimination, the character of rectrice moult of pheasants alone held my interest, I carefully reviewed the specimens and evidence, and confirmed my results. Nevertheless, let me emphasize, what, in the stimulation of the discovery of what appears to be a new, significant, taxonomic factor, one is apt to forget,

1. A Hand-List of the Genera and Species of Birds, Vol. I. pp. 33-40.

that the best of such characters is only a make-shift, a mere tentative bridge to tide over both our ignorance and the gaps made by time and space in the succession of organic forms. If tomorrow a more consistent, logical factor be discovered, I shall discard the tail moult without a regret. It seems to serve for the present, as being consistent throughout the family, and more fundamental than some other characters. Quite significant and confirmatory is the fact that, instead of inaugurating wholly new arrangements and juxtapositions of genera, it corresponds in a general way with the classifications, more or less theoretical, of earlier taxonomists.

While one would think that the Tragopans were pheasants rather than partridges, using the former term in the usual loose way, yet when we compare them with other genera on the border line, we find that there is no reason, either of sexual difference in coloration, elaborateness of courtship or other feature which actually sets them apart. *Arboricola, Rollulus, Melanoperdix, Ptilopachys, Bambusicola, Galliperdix, Ithaginis,*—all have been considered too near the border line, and too much alike, to be separated from the pheasants by any line of distinction. And yet the pheasants as a group, and on the other hand the quail and partridges as a group, are in our minds, very distinct in a general way. So even if *Tragopan* has to be sacrificed, it has seemed worth while to recognize this sharp line of demarkation, falling between *Tragopan* and *Lophophorus,* which the tail moult offers, as at least the best division character yet available, for the marking off of sub-family groups.

In connection with the moult of the tail, Dr. Bureau writes of *Perdix cinerea*[1]: "Il est bon de faire remarquer que la chute et le remplacement des rectrices se font très régulièrement de dedans en dehors, c'est-a-dire du milieu de la queue vers le bord externe." This I found to be invariably the case both with *Ithaginis* and *Tragopan,* that the moult of the tail *begins with the central rectrices and proceeds regularly outward.* Although I have not been able to examine all of the twenty-odd genera associated with *Perdix,* such as *Caccabis, Francolinus, Arboricola, Coturnix,* etc., I am satisfied that this character holds good throughout and would therefore class *Ithaginis* and *Tragopan*

1. l'Age des Perdrix, I. p. 70. ("*P. cinerea*" = *P. perdix.*)

with the Francolins, European Quail and Partridges as the sub-family *Perdicinae.*

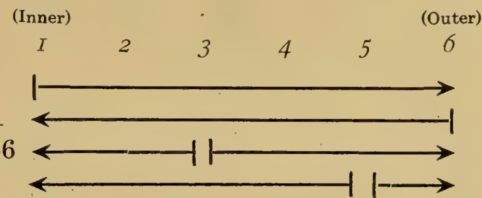
With no gradual transition, but abruptly as it was unexpected, the student of moult in the group of pheasants, finds in *Lophophorus* and the succeeding genera, the tail feathers moulted *from without, inwards.* Just as in *Perdix* and *Ithaginis* one finds the outer pair or pairs of juvenile rectrices or, in adults, those of the previous year, persisting for some time after the others have been shed, so in this second sub-family it is the inner pair which is the last to fall. The sub-family *Phasianinae,* as I define it, includes *Lophophorus* (+*Chalcophasis*), *Acomus, Lophura* (+*Diardigallus*), *Lobiophasis, Crossoptilon, Gennaeus, Catreus, Pucrasia, Syrmaticus* (+*Calophasis,*+*Phasianus, partim*), *Phasianus, Chrysolophus,* and *Gallus.*

When I first examined the moulting rectrices of *Argusianus* and *Polyplectron* I was at a loss to explain the apparent confusion, and my new factor seemed about to fall to pieces. The feathers appeared to sprout at random. But nevertheless I tabulated them in the order of their growth in every individual which showed such a condition and when the results were compared I was delighted to find a wholly unexpected agreement, and the third sub-family took form, to which I have given the name *Argusianinae.* This includes *Polyplectron, Chalcurus, Argusianus* and *Rheinardius.* In these birds the moult of the tail begins with the 3rd from the central pair and proceeds outward and inward, the 2nd and 1st pairs falling respectively between the 4th and 5th, and the 5th and 6th pairs.

Perhaps most distinct from all the other groups, and well placed last in the series of Phasianidae genera, are the Peafowl. *Pavo* is set apart by many characters, and it is gratifying to find that this isolation is borne out in the moult of the tail, by which we may characterize it *Pavoninae.* The 2nd pair from the outer falls first, and there follows a regular progression inward, the outer pair being moulted just before the inner ones. This sequence is invariable, both in the ten pairs of rectrices of the cock, and the nine pairs of the peahen.

We may thus sum up the criteria of sequence of rectrice moult as follows, numbering from the central pair of tail-

feathers outward, and assuming in each case for the sake of simplicity, that there are but six pairs:



Perdicinae: 1-2-3-4-5-6
Phasianinae: 6-5-4-3-2-1
Argusianinae: 3-4-2-5-1-6
Pavoninae: 5-4-3-2-6-1

Let me reiterate that I hold this character of tail moult of value only in so far as I have tested it among pheasants. Indeed the more I realize the great number of the factors concerned in evolution, the more I appreciate that any classification must finally be the result of a balanced weighing of equally varied characters. While tail moult may, and it seems to me, does represent a valuable character in dividing the *Phasianidae*, it may, on the other hand, be wholly useless in connection with any other family of this order.

Genus *Ithaginis.*

I have little to add to my recent paper on this genus.[1] Further study of northern specimens has confirmed the conclusions of Bianchi [2] so that the present status of members of the genus of Blood Pheasants or, as I shall call them, Blood Partridges, is as follows:

Ithaginis cruentus cruentus (Hardwicke).
Ithaginis cruentus affinis Beebe.
Ithaginis geoffroyi Verreaux.
Ithaginis kuseri Beebe.
Ithaginis sinensis sinensis David.
Ithaginis sinensis michaëlis Bianchi.
Ithaginis sinensis berezowskii Bianchi.
Ithaginis wilsoni Thayer and Bangs.

1. New Blood Pheasants, Zoologica, Vol. I. No. 10.
2. Annuaire du Mus. l'Acad. Imp. Sci., St Petersburg, t. VIII. p. 1.

ITHAGINIS KUSERI.

Some time after I had confirmed my 1910 discovery of this species by the mounted specimens in the Museum of the Jardin des Plantes, Dr. Eagle-Clarke was kind enough to send me a rather young male *Ithaginis* in full moult and of unusual interest. It bore the locality Yunnan on the label and upon careful examination I came to the conclusion that it was *Ithaginis kuseri,* but an abnormal individual. In no species of this genus is there normally an increase in pectoral scarlet after the first post-juvenile moult, but in two or three individuals I have found an abnormal abortive condition of pigmentation in young birds and this seems another; the degenerate rusty-buff pigment stains on the pectoral plumage being replaced by crimson in the feathers of the succeeding moult.

Since discovering Kuser's Blood Partridge in northern Yunnan, I have been informed by Dr. Annandale of the Indian Museum, Calcutta, that it has been found in the Mishmi Hills by Capt. F. M. Bailey at an elevation of twelve thousand feet, replacing there the Sikhim species. So that it is probable that the species extends in an unbroken range westward from Yunnan to these mountains. This implies a highland connection between the two regions, and also explains the reason for my unexpected extension of the range of Sclater's Impeyan Pheasant (*Lophophorus sclateri*) from the Mishmi Hills to northwestern Yunnan.

EARLY PLUMAGES OF *ITHAGINIS.*

The Blood Partridges comprise almost the only genus of those which lie close to the limits of my research, which have not been extensively kept or bred in captivity, so that in their case the changes of plumage have neither been observed nor described. The latter fact is indeed true of a considerable number of more widely known species of the pheasants, but I shall postpone the description of these others, and give only the ontogenetic development of the plumage of the Himalayan and the Chinese Blood Partridge.

ITHAGINIS CRUENTUS.

Natal Down.—Chick about a week old; general color scheme —head and neck gray and white, body rufous.

Loral and malar streak, circle around eye, large infra-auricular spot and line extending backward around the nape, center of crown and wide nuchal band, brownish-black. Remainder of head, throat and neck pale grizzled gray. Beginning abruptly at the lower neck all around, and backward over entire body, the down is dull rufous with slender black tips, except on the under parts, where the rufous is paler and purer. A central dorsal and two lateral stripes are paler, more buffy.

Seven primaries, eight secondaries and several greater wing-coverts even at this early age are well in evidence, the former having pushed out about 15 mm. beyond their sheaths, the wing measuring 46 mm. The down clinging to the tips of the growing flight-feathers is rarely in a single distal cluster, but more commonly with the separated down filaments supported on the extremities of several distal barbs. The sprouting wing feathers are of unusual breadth, dark brown, mottled irregularly with buff, and tipped with pale buff. Bill from nostril 6; tarsus 23 mm.

Juvenile Plumage.—Bird about five weeks old. The dorsal plumage is uniformly of a dull mottled buff and black, each feather with a very conspicuous, terminal, triangular spot of pale buff. The ventral pattern is a wide, buffy-white shaft-stripe bordered irregularly with darker brown, with the margin of the feather pale buff.

As the head and neck are the last to lose the nestling down, so their first contour covering is correspondingly more advanced in color and pattern than the mesoptile body feathers, and hints strongly of the adult plumage. The facial area is but scantily covered with featherlets, the anterior crown is buffy, while the nape and neck show traces of the blue color and white shafts of the adult. The latter is the first certain evidence of the male sex.

The full-grown juvenile tail-feathers are fourteen in number, and measure but 84 mm. in length as compared with 170 in the adult. In shape they are slender, rather pointed and falcate,

curving slightly outward and noticeably downward. In color they are rufous-buff barred with dark brown. The delayed 7th to 10th primaries do not finish their growth until the body-moult into adult plumage is well on toward completion.

The post-juvenile moult into the first winter plumage brings the members of this genus into fully adult dress.

Ithaginis sinensis.

Natal Down.—When compared with the corresponding chick of *Ithaginis cruentus* many differences are noticeable. The head and neck with the cold gray, almost white, and black markings are similar, but the down of the entire body, above and below, is very much colder and grayer in *sinensis*. Instead of warm rufous-buff above, there is only a trace of this on the mantle down. A central back stripe is grizzled grayish-brown and two lateral stripes are pale creamy buff. The breast has a tinge of buff, but this hue is scarcely noticeable on the rest of the ventral surface, the chin, throat and belly being white.

Juvenile Plumage.—This too is unlike the corresponding stage in *cruentus*. The forehead and crown are not buff but a grayish brown, banded with black and buff on the occiput and nape. The color of the upper surface is distinctly grayer, the terminal pale buff spots thus standing out much more clearly. The black bars on the wing-coverts are also more distinct. The ventral pattern is wholly unlike that of *cruentus*. There is no trace of the pale buff shaft-stripe, but the feathers are a brownish buff, indistinctly marked with darker and tipped as on the dorsal plumage with a pale buff shaft-spot. This is especially distinct on the breast and upper belly, the feathers posteriorly becoming very loosely vaned, all distinct characters being lost.

Genus *Tragopan.*

Unlike Blood Partridges, the Tragopans do not acquire the adult plumage until the second autumn. Many wholly unsupported statements have been made concerning the early plumages and moults of these birds, the general impression being that the change from the juvenile to the first year plumage, and from this to the adult dress is a gradual process; if not by a

gradual change of color within the feathers themselves, at least by a slow replacing of feathers throughout many months. One finds abundant evidence of this belief, even from collectors' notes on labels, such statements as "young bird in moult" being applied to specimens on purely superficial circumstantial evidence of color and pattern, in cases where there was not a growing feather in the entire plumage.

In this genus and in *Lophophorus* and others, the cause for this error is easily found. The head and neck of the chick remain clothed in down long after the contour feathers of the body have appeared. When at last the anterior plumage replaces the down, it grows very rapidly, but in the space of a few weeks the pigment secretions have undergone radical changes and instead of the feminine browns and grays of the juvenile body plumage, the young male usually shows a parti-colored head and neck, differing very much individually, but usually intermediate in color and pattern between juvenile and adult. Thus the superficial impression conveyed during the succeeding twelve months is of a bird in partial moult. This is heightened by adventitious feathers which appear here and there on the body, perhaps a single feather of glowing metallic emerald set off by the surrounding dull brown. For so rapid are the anabolic changes which alter the internal secretions, that within seventy to ninety days after a purely juvenile feather has finished its growth, if it be accidentally pulled out, it will be replaced by a fully adult one. After the second winter's fully adult plumage has been acquired, this incongruity in pattern and pigment is of course no longer apparent.

Without going at present further into details, the sequence of plumages of a bird such as a male *Tragopan satyra* is most interesting and suggestive.

We find

(a) A down plumage of definite regional patterns.
(b) A juvenile plumage of definitely patterned feathers.
(c) A first winter's plumage of very generalized, female-like coloration.
(d) An adult plumage exceedingly specialized both as to region and feather, color and pattern.

Key to female *Tragopans.*

This rather difficult task has been attempted several times, perhaps most successfully by Prof. Ghigi.[1] Even this, however, fails when the variations of the ocelli on the plumage of several scores of females are taken into account. I offer the following as a substitute:

A. Dorsal plumage streaked with white.
   a Gray dominant on ventral plumage.................*melanocephalus*
   b White or buff dominant on ventral plumage...................*caboti*

B. Dorsal plumage not streaked with white.
   c Bend of wing not orange rufous...................................*temmincki*
   d Bend of wing rich orange rufous.
      a′ General tone olive; black ocelli dominant on dorsal plumage ....*blythi*
      b′ General tone cream-buff; black ocelli not dominant on dorsal plumage ....*satyra*

Chalcophasis vs. *Lophophorus.*

However much we realize the impossibility of giving equal weight to corresponding taxonomic characters when dealing with families and orders, we should certainly be able to give to the genera in any one sub-family or family a more equally correlated value. I can find no grounds for the separation of the species *sclateri* from the genus *Lophophorus.* When we begin to separate individual species in the genera of *Phasianinae* we soon get into trouble. If we admit *Chalcophasis* we must split *Gallus* into three genera, as *Gallus gallus, sonnerati* and *varius* exhibit as great differences among themselves as exist between *impeyanus* and *sclateri.* Neither of these changes is desirable or necessary. *L. sclateri* is worthy at most, of only sub-generic distinction.

Genus *Lophophorus.*

Careful study and comparison of many scores of specimens of this genus prove conclusively that the following are the only valid forms:

1. Studi sul genere Tragopan Cuvier. Memorie della R. Accademia delle Scienze dell' Istituto di Bologna. Serie V. Tomo X. p. 14.

Lophophorus impeyanus (Latham).
Lophophorus lhuysii Verreaux and St. Hilaire.
Lophophorus sclateri Jerdon.

As synonyms of *L. impeyanus* I class *refulgens, chambanus, mantoui* and *obscurus.* In regard to the much-discussed question of *impeyanus* vs. *refulgens* and *chambanus,* aroused by Latham's black-backed monaul, [1] it is surprising that the attention of the opposing factions has been confined solely to the descriptions and plates in the earlier works of this author. Latham himself settles all doubts on this question in his *General History of Birds*[2] where he says: "In the drawing of Lord Mountnorris, is one of the male, with a large patch of white in the middle of the back, which I have not seen in any other representation of this singularly beautiful species."

So the assumption[3] is correct that Latham was describing and picturing a black-backed individual, but the acceptance of the several black-backed male birds from Chamba as a distinct species is an error. Examination of all the known specimens show as great a variability *inter se* as the difference between them and normal male *impeyanus.* This is evident from the following tabulation of the characters supposed to be diagnostic of the black-backed birds:

"Under-parts entirely glossed with metallic golden-green."

This gloss may be

(a) Typically like the above description.
(b) Confined to the breast and irregularly down one side.
(c) Confined to the throat and upper breast.

"Upper tail-coverts chestnut, tipped with golden-green."

(a) Typically like above description.
(b) An excess of green with a little basal rufous.
(c) As in normal *impeyanus.*

"Lower back golden-green."

This whole area is decidedly abnormal, as the metallic tips are so very small that they are completely separated and dominated by the loose, fluffy basal down, giving the appearance of half the normal number of feathers of this area having been lost. No such scanty, abortive metallic

1. Latham, Gen. Syn. Suppl. I. 1787, p. 208, pl. 114. id. Index Orn. II. 1790, p. 632.
2. Gen. His. Vol. VIII. 1823, pp. 210-11.
3. Grant, Cat. Birds Brit. Mus. XXII. p. 280.

> coloring occurs on any normal plumage of which I have knowledge. In typical, white-backed individuals a small amount of metallic color sometimes persists on all the white feathers.

In the presence or absence of the copper collar and the extent of the green mantle there is as great variation as in the above mentioned characters.

When in Garhwal and Kashmir I did everything in my power to learn something of the black-backed Monauls, but of two men who had seen them, one had nothing of interest to relate while the other stated that the bird was feeding with several white-backed individuals. No female has ever been found, and *chambanus* is unquestionably a mutation, sport or abnormal variation as one may choose to call it.

The so-called *mantoui* and *obscurus* are of the same nature, no two individuals corresponding exactly to the types, while some show startling variations such as glossy, greenish-black tail-feathers.

It was interesting to find that *Lophophorus*, according to my classification, has much closer affinities with the true pheasants and *Pavo* than with *Tragopan* and the *Perdix* group. Beside the moult of the tail-feathers, other characters serve to strengthen this bond.

Diardigallus vs. *Lophura*.

This case is similar to that of *Chalcophasis* and *Lophophorus*, and I can find no character which warrants the generic separation of *diardi* from *Lophura*.

Genus *Lophura*.

Although the species of this genus do not show any greater variation from the normal than many of the other pheasants, yet atypical individuals have caused great confusion. After careful comparison of all the specimens I could find in the museums of the Far East, of Europe and of America, together with those I was able to collect, I can find no sufficient grounds for separating the Sumatran from the Malayan birds, nor of recognizing

the single aberrant captive specimen from an unknown locality, now in the Leyden Museum, as distinct from the Bornean Crestless Fireback.

If, on the other hand, such characters as have been utilized in the separation of these two forms are recognized as valid, then I should logically be compelled to distinguish three or four other "species" based on equally variable and, it seems to me, insufficient characters. I have in mind, one male bird with half the mantle of clear chestnut, and another full-grown male with the central rectrices half chestnut, instead of pure white, both wild shot birds. It is wholly impossible to separate the Sumatran birds on the ground that the shaft-stripes of the side and flank feathers are predominately buffy or chestnut rather than white. Over fifty per cent. of the Malayan birds show considerable chestnut on these feathers, and an adult male sent to me in the flesh from Johore to the Raffles Museum, Singapore, exhibited a greater amount of chestnut-red flank markings than I have seen on any Sumatran bird. Such being the case, I see no logical possibility of distinguishing more than a single species of this northern Crested Fireback. As to *sumatrana* as defined by Buttikofer,[1] the variation *inter se* of the five male specimens which he lists is such as to give but slight value to the status of this form. I have seen at least a half dozen adult specimens in the museums of the East and elsewhere, which show as much variation in the chestnut and white of the rectrices and the amount of red on the flanks as in the above mentioned five birds. As these specimens were divided between Sumatra and Pahang, I see no course open but to consider them as aberrant variations of *rufa* in the direction of *ignita*.

Lobiophasis bulweri.

The sequence of plumage of this splendid Bornean bird, the White-tailed Wattled Pheasant, has heretofore been rather misunderstood. The fully adult plumage is acquired at the third annual moult.

The downy chick moults into a juvenile plumage of rufous brown, finely vermiculated with black. This stage is especially characterized by the rich golden rufous of the tips of the wing-

1. Notes from Leyden Museum, XVII. 1895, p. 177.

coverts, many of which have a very distinct black, oval ocellus on each web, framed in the golden space. The tail-feathers are dark chestnut, slender and pointed.

The post-juvenile moult into the first year plumage initiates but little change in general appearance, the rufous being richer and many of the feathers having dark tips, while about the neck, except on the nape, is a more or less distinct, wine-colored collar. The rectrices are broader and longer and there are twelve pairs of tail feathers in this plumage. At the succeeding moult, that of the second year, the body plumage of the male becomes very like that of the adult, the chief difference being in the less development of the concave, terminal band of shining blue. As a result of this the crimson of the breast is very pronounced. The rectrices, now as many as thirty-two in number, are rich rufous and very broad.

A few weeks after this moult is completed, if a tail-feather be accidentally pulled out, the one which replaces it will be pure white, but in size will approximate the rufous feathers on either side. Thus while the normal rufous outer tail-feather of this plumage is about 117 mm. in length, and the corresponding white feather of a fully adult bird 218, an adventitious white feather appearing a short time after the previous moult will be intermediate between the two. In this case the pigmental maturing long antedates the change in size, and thus is avoided the danger which a single, long, white projecting feather might bring down upon the immature bird. Strange to say, much of the rachis of such an adventitious tail-feather is quite as bare as in the adult, the factor of structure being again distinct from that of size.

In the adult bird, while the white of the tail is uniform and complete, on the wing feathers this is as yet in process of development. Some individuals show hardly a trace of the white color, but in the richest plumaged birds as many as nine of the primaries will be white, chiefly on the basal half or third.

Genus *Crossoptilon.*

Of the five usually recognized species of this genus I can accept but three, and indeed I am not wholly satisfied that two

of these are of more than sub-specific rank, making but two full species.

Crossoptilon mantchuricum Swinhoe.
Crossoptilon auritum (Pallas).
Crossoptilon tibetanum (Hodgson).

A review of the specimens of the two latter species in many museums shows that all the birds from the eastern part of the range are the normal blue-gray *auritum,* while those from the western part, in Tibet, are typically snow-white *tibetanum.* In intermediate localities have been found not only typical specimens of each, but also many parti-colored birds to some of which has been given specific rank. These are, in my opinion, examples of that very unusual phenomenon in nature,—hybridism, between the two very distinctly colored forms. No other explanation seems open.

As regards *harmoni,* all recent describers of the type have merely copied an earlier description and have perpetuated several errors. Such as omitting to mention the posterior extension of white on the throat and the white on the center of the belly. These and other characters are all found combined in various ways and degrees of development in other individuals collected in different parts of Tibet. For example, in the Jardin des Plantes Museum there is a bird, typically *harmoni* in all respects except that the whole abdomen from the lower breast downward is white and the outer six pairs of rectrices have a great deal of pure white. These feathers number only twenty, and a very careful examination of the root of the tail showed that none had been lost. In view of the observations which follow there is no reason to credit the type specimen of *harmoni* with having originally had more than twenty-two, or even twenty rectrices.

Crossoptilon leucurum has been separated from *tibetanum* on account of the presence of white in the tail feathers, but the fact that no two individuals exhibit the same amount of this color, or even show it symmetrically distributed on the right or left feathers, wholly discredits this character as of taxonomic importance. Indeed Hodgson's original type of *tibetanum* shows white on all the six outer pairs of tail feathers.

To careless examination and description is due much of the confusion existing among the birds of this genus. Instead of having twenty tail feathers, the majority of the *leucurum*-like individuals have twenty-two. The male type possesses twenty at present, but a glance at the skin surface over the pygostyle shows two gaping holes from which the other pair has been pulled, while the female type still has twenty-one, the outer left rectrice having been lost.

In the latter bird the rectrice white is present only as a small spot on the outer tail-feathers, but increases rapidly until it dominates the next to the central pair. In another specimen the reverse arrangement is found. In two *leucurum*-like birds with very little white, there are only twenty as the full complement of tail feathers. And so, to be logical we must stretch the description of *harmoni* and of *leucurum* to include a multitude of variations, or make new species of almost every individual, or, to follow the only reasonable course of action, both must be sunk as synonyms of one or the other species. Hybridism seems the only explanation of such variation and asymmetry.

The variation in number of tail feathers in *Crossoptilon* is of interest. In *tibetanum* there are twenty, and all with vanes quite solid and normal in structure. The whiter *leucurum*-like birds show no change, but in most of those individuals which approach *harmoni* and *auritum,* an extra central pair of highly disintegrated feathers appears, *above* the others, suggesting, from their position, derivation from the upper tail-coverts. In *auritum* still another pair is present, making twenty-four in all, this additional pair also being central, superior, and much disintegrated. So the specialization is definite as to position. In more than one bird, which in color from beak to tail is typical *auritum,* I have found after careful macro- and microscopical examination only twenty-two rectrices; none having been lost accidentally, but one of the central pairs being congenitally absent. These birds were unquestionably hybrids with the lessened number of rectrices as the sole indication of their mixed blood.

In the rather isolated, more generalized, brown *mantchuricum,* twenty-two is the normal number, and here we find but a

single pair of central, superior, disintegrated tail feathers, showing that the locus of specialization is the same as in the other species.

In the presence or absence of certain rectrices in these birds we encounter another of those unexpected correlations which meets the student of avian evolution at every step. As regards color there is no doubt but that the snow-white *tibetanum* birds are by far the more specialized. White is always an extreme achievement in pigment radiation or rather elimination, and their colored young show how recently the adult hue has been acquired. But on the other hand, the greater number of four and twenty tail feathers in the blue-gray *auritum* is in its way, as extreme a specialization—excelled in the family *Phasianidae* only by the adult *Lobiophasis*. Thus the complexity of evolution is forever being impressed upon us—specialization correlated with generalization and vice versa in closely related organisms. Only by the sum total—the balance after the intricate addition and subtraction of all its character units, and even then only by visualizing the genealogy in three planes of space—can we ever hope successfully to orient any species in relation to its predecessors and contemporaries.

Genus *Gennaeus*.

Along the southern slopes of the Himalayas as well as in Burma, Yunnan, China and elsewhere I obtained an unusually complete collection of these interesting and puzzling birds, and especially a series of immature and moulting individuals, some of which prove beyond question that hybridization has had much to do with the excessive variation, which has given cause for the making of almost forty species.

Unfortunately I was obliged to postpone my desire to examine the Oates' collection of *Gennaeus* in the British Museum, which contains fourteen or fifteen types. Published descriptions of these birds are, on the whole, so meagre as to lesser details, and based in many instances on such exceedingly superficial diagnosis that I do not feel justified in publishing a summary of my observations until such time as the accessibility of the types to visiting ornithologists will provide data on which to base definite and final conclusions.

GENUS *PUCRASIA*.

The Koklass Pheasants seem to exhibit many difficult problems. The intricate colors and patterns of their plumage, the individual variation, and the wide and irregular distribution, all make toward confusion at first thought. In reality, however, when we eliminate the useless characters and correct the errors due to hasty species diagnoses, the genus proves to be one of the most interesting and suggestive of all the *Phasianinae*. Its various forms reveal one of the rarest phenomena in nature—a wide-spread series of delicate gradation, and increasing complexity within a single, closely related group of living creatures. There is no room for doubt but that we can trace the exact route which these birds have taken in past years, starting in Garhwal in the western Himalayas and after a long trek northward, eastward and southward, reaching the seacoast in southeastern China.

I recognize the following three species, comprising ten subspecies of this genus:

Pucrasia macrolopha macrolopha (Less.).
Pucrasia macrolopha biddulphi Marsh.
Pucrasia macrolopha castanea Gould.
Pucrasia macrolopha nipalensis Gould.
Pucrasia xanthospila xanthospila Gray
Pucrasia xanthospila ruficollis David and Oustalet.
Pucrasia xanthospila meyeri Madarasz.
Pucrasia xanthospila joretiana Courtois.
Pucrasia darwini darwini Swinhoe.
Pucrasia darwini styani Grant.

The character upon which I place most importance in the definition of full species in the genus *Pucrasia* is the increasing complexity of the mantle pattern (extending also to other parts of the plumage) in the males. In *macrolopha, xanthospila* and *darwini* this pattern may correctly be described as single, double and quadruple respectively.

In *macrolopha* the mantle feathers are cold ashy gray with a wide, black shaft-stripe extending almost to the tip. Careful examination of the base of the feathers reveals the fact that

a white wedge has been driven some distance up the shaft, but this *anlage* of a splitting of the black stripe is not visible when the feathers are in place.

In *xanthospila* and its congeners the central wedge of light color has spread up the entire vane and there are two lines of black instead of one.

In *darwini* the third and most complex development of the pattern is found. Two additional lateral white wedges have appeared, splitting the two longitudinal black lines into four—the quadruple pattern. Thus the devolopment and geographical distribution must have been from *macrolopha,* through *xanthospila* to *darwini.*

Pucrasia macrolopha macrolopha and Its Allies.

The Koklass Pheasants from Kumaon and Garhwal (*P. macrolopha macrolopha*) are undoubtedly the most generalized of the entire genus. Going westward and eastward from this point we find the birds becoming more and more specialized in color but not in pattern, until in Afghanistan in the one direction and central Nepal in the other, the two extremes are encountered. In fact *macrolopha* is, without question, the center of radius for all the other geographically adjacent members of the genus. For example in a large series of specimens, all from central Kumaon and Garhwal, we find strong hints of the following:

Chestnut darkening ventrally and encroaching on mantle, typical *macrolopha* back—toward *biddulphi* and *castanea.*

Chestnut darkening ventrally and encroaching on mantle, dark back—toward *nipalensis.*

Distinctly yellow mantle—toward *xanthospila.*

In many specimens there are distinct shaft-streaks of chestnut not only on the high neck but even low down on the mantle and as we go westward the birds merge into *biddulphi.* On many Koteguhr birds the ventral chestnut is very wide spread and fully as dark as in *castanea.* The more extreme

castanea forms vary much among themselves in this character, two which I have seen being exactly intermediate between *castanea* and *buddulphi*. Gould's statement that *castanea* is "altogether a stouter and larger bird than *Pucrasia macrolopha*" is wholly without foundation, and was based on the superficial appearance of his very much overstuffed type specimens. Careful comparisons show practically no difference in size, and where there is, the slight increase is in favor of *macrolopha*. There is no alternative but to give only sub-specific rank to these two forms, although even trinomials do not tell the whole truth, as *biddulphi* lies between *castanea* and *macrolopha*. They fully deserve this distinction, however, as the variations are clearly geographical.

East of Kumaon we find the Koklass Pheasants becoming more and more dark over the entire plumage, while the chestnut appears on and spreads over the mantle. Many of the so-called specimens of *nipalensis* from Jumla, western Nepal, and the vicinity, are indistinguishable from the more dark-mantled *macrolopha* from Kumaon. No description has ever been given of the extreme *nipalensis* type; all relate to intermediate specimens, so I offer the following diagnosis of *Pucrasia macrolopha nipalensis*:

Adult Male.—Head and neck as in *macrolopha*, except that the crown and the shorter part of the crest is warm rufous buff. The hind neck and mantle are dark chestnut, the black being confined to the tip and two narrow, lateral lines down the center of the webs. On the upper back the chestnut dies out as a narrow shaft-streak. The back is black with scarcely a trace of white edging, but on the lower back a light margin persists and on the rump and upper tail-coverts this increases in width and becomes tinged with buff. The chestnut of the mantle is continued directly on to the scapulars, tertiaries and inner secondaries; on the former as a bright shaft-stripe and on the inner web, increasing and paling posteriorly, until on the inner secondaries it covers most of the feather, as a clouded, but still rich, rufous. It decreases to a shaft-stripe on the succeeding secondaries, and on the primaries covers the narrow outer web with a warm rufous buff. The lesser wing-coverts are jet black, the greater dark brown, uniform for the most

part, but here and there with an evanescent narrow fringe, white on the lesser, rufous on the greater coverts.

The tail is entirely free from gray or sandy color, and only the shorter upper tail-coverts show even the buffy-white fringe of the rump. The longer ones are similar to the central rectrices, chestnut with a central line of black. The chestnut persists strongly even on the outer feathers, while the narrow white fringe is most pronounced on the outer ones and dies out before it reaches the central feathers.

On the under parts the dark chestnut is developed only to about the same extent as in *macrolopha,* except of course on the side neck, where it joins that of the mantle. But I have seen individuals of otherwise typical *macrolopha,* which had more ventral chestnut than any Nepal bird. The sides of the breast and belly show no trace of ashy, but are dull jet black, with, as on the wing-coverts, adventitious hints of whitish fringe. This is wider and more distinct on the flanks. The under tail-coverts are rich light chestnut.

There is not a single character quoted above which may not be found in all conditions of gradation between the extreme here described and the extremely pale form of *macrolopha.*

It differs from the *castanea* off-shoot in combining intense melanism with increased erythryism, while *castanea* shows the latter only on the mantle and ventral surface.

Adult Female.—The females, within much more narrow limits, show as much variation as do the the males, but the extreme reached through a series of gradual steps shows decided erythryism, both on the dorsal and ventral surfaces. The whites of *macrolopha* become buffs; the buffs of the western form are warm rufous buffs in *nipalensis.*

PUCRASIA XANTHOSPILA AND ITS ALLIES.

As we have seen, the Koklass Pheasants of the extreme western Himalayas and of central Nepal develop chestnut mantles. Those of Tibet and of Northern China acquire a less extensive but very distinct yellow dorsal collar. This is foreshadowed in about twenty per cent of *macrolopha macrolopha,* in

which a strong yellow buff tinge is present about the side and hind neck. The mantle stripe is doubled as I have already described, and the geographical hiatus of Tibet, in which we know of no intermediates, requires that the northern forms be considered a distinct species.

P. xanthospila meyeri may be considered somewhat of a linking form, for while possessing to an extreme degree the double dorsal pattern of *xanthospila,* it still retains the rufous rectrices of *macrolopha.*

P. xanthospila ruficollis is a well-marked form from Kansu, not to be considered more than a sub-species owing to the great individual variation in both amount and shade of the yellow collar in more typical *xanthospila.* A third, *P. xanthospila joretiana* has recently been found with characters tending in the direction of *darwini.*

Thus we find a second hiatus between forms possessing the double and the quadruple pattern, a specific gap which is apparently real and only partly bridged by *joretiana.* Hence the birds of southeastern China form the third *darwini* group, all characterized by the complex dorsal pattern.

In *darwini,* the yellow mantle is lost, the colors being as in *macrolopha,* while the oblique black tail-band of *xanthospila* is broken in both sexes. There is a decided diffusion and weakening of the ventral chestnut, even in the strongest marked birds, which may be taken as the more typical. In a series collected in one locality in Fokien, the greatest variation is found in the presence or absence of this chestnut, and in more than one specimen it is wholly lacking as a recognizable factor in the ventral patterning.

In describing *Pucrasia styani* from Ichang, Mr. Grant selected a male which differs in no respect from the extreme *darwini* birds in the British Museum series. What he mentions as a "second male" is an extreme in *styani* coloration, the chestnut having been eliminated not only as a solid, central, ventral marking, but also from all the rest of the body plumage, making the bird, as a whole, of the clean black and gray type of coloring, which in *darwini* is found only on the mantle. We thus accord the Ichang birds only sub-specific rank, *Pucrasia darwini styani.*

Genus *Phasianus.*

My studies of the birds of this genus are not complete and I shall not touch upon them at present except in the following pages with reference to the *soemmerringii* group.

Genus *Syrmaticus.*

This genus has heretofore contained but a single species, *reevesi.* As the result of careful comparative study I have expanded it to include five additional species, as follows:

Syrmaticus reevesi Gray.
Syrmaticus ellioti (Swinh.).
Syrmaticus humiae (Hume).
Syrmaticus burmanicus (Oates).
Syrmaticus mikado (Grant).
Srymaticus soemmerringii soemmerringii (Temm.).
Syrmaticus soemmerringii scintillans (Gould).
Syrmaticus soemmerringii ijimae (Dresser).

A superficial glance at the males of such pheasants as Reeves, Elliots, Mikado and Copper shows a diversity of color which seems to have nothing in common. But in the greatly elongated and narrowed central rectrices and a number of other characters we find that they agree, and differ from the other nearly related genera. In the females also we find real criteria of relationship.

Taking females of these six species and placing them side by side we are at once struck with the great similarity of their rather specialized colors and patterns. Comparison with the corresponding sex of related genera emphasizes this similarity.

The following tabulated characters will serve to illustrate this:

Syrmaticus Females.

a—Lateral rectrices always dominantly rufous; with subterminal black and terminal white bands.

b—Breast solidly or heavily marked; belly wholly or dominantly white.

c—Mantle with conspicuous white, arrow shaft-marks, or, *soemmerringii* a pale shaft line or terminal streak.

d—Central one or two pairs of rectrices with very indistinct cross-bars (except *mikado*), and strikingly unlike the 3rd and other lateral pairs.

Comparing these characters with those of *Phasianus* for example, we find the lateral rectrices with little or no rufous and barred throughout; the central rectrices not differing from lateral ones and with distinct cross-bars; the breast never decidedly distinct in pigmentation from the rest of the ventral surface; the mantle never with white or pale shaft-streaks.

The disintegrated, hair-like condition of the rump feathers in the males of true *Phasianus* becomes an important character, diagnostic of the genus when the *soemmerringii* group is removed. This is wholly absent from the *soemmerringii* group and *Syrmaticus* as I define it. As to intra-generic differences; (1) *ellioti, humiae, burmanicus* and *mikado* possess sixteen rectrices, while *reevesi* and *soemmerringii* have eighteen. In this instance the remarkable resemblance between the females certainly is a more fundamental and important character than the difference of a pair of tail feathers, when, to quote but a single illustration, we remember that in the genus *Gallus, varius* possesses one pair of rectrices more than *gallus*. (2) The extreme difference in color of the males would seem to militate against uniting them in a single genus, until we consider the parallel case of *Chrysolophus* where the Golden and Amherst males present very diverse patterns and colors. The genus *Syrmaticus* as I define it seems a logical assemblage of forms, capable certainly of sub-generic division, but on the whole differing in no more important characters than occur in other phasianine genera.

Genus *Gallus*.

See note under *Chalcophasis*, p. 270.

Gallus aeneus, temminckii and *violaceus* are neither "distinct species" nor "domestic varieties" but first generation hybrids between a wild cock *varius* and a domestic hen, known to the Javanese as Bekisars.

Gallus aeneus Cuvier, is one of the hybrids with violet upper plumage, margined with golden yellow; comb with minute teeth, and a small median wattle.

Gallus temminckii Gray, is the red phase of hybrid. All the plumage is margined with golden chestnut; six coarse teeth in comb; well developed median throat wattle and small gular wattles.

Gallus violaceus Kelsall, has the violet gloss dominant, a toothed comb and a good-sized median wattle.

G. stramineicollis is merely a large variety of domestic fowl.

After studying all four species of feral *Gallus* in their native haunts, as well as many examples of natural and artificial hybridizing, and reviewing the evidence from all points of view, I can find no reason to attribute the ancestry of all varieties of our domestic fowls to other than the Red Junglefowl of India, *Gallus gallus* (Linnaeus).

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THE PORPOISE IN CAPTIVITY

BY

CHARLES HASKINS TOWNSEND, SC. D.
DIRECTOR NEW YORK AQUARIUM

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FIG. 1. BEACHING THE PORPOISE SEINE, HATTERAS, N. C.

THE PORPOISE IN CAPTIVITY

By CHARLES HASKINS TOWNSEND,
Director of the New York Aquarium.

Illustrated with photographs by E. R. Sanborn and the Author.

The New York Aquarium has a school of porpoises and lays claim to the world's best single exhibit of captive wild animals. It is fascinating to have these lively rangers of the open ocean actually dwelling in our midst. They are the same "jolly porpoises" that make high speed dashes under the bows of ships. No more popular exhibition of wild life has ever been made anywhere. After seven months in a circular pool thirty-seven feet in diameter and seven feet deep, they remain in good condition, feeding, leaping and otherwise disporting themselves after the manner of porpoises on the high seas. There are five of them and their playful splashing throws showers of water over visitors who venture too close. The exhibit is unique, as there is no other Aquarium in America or Europe equipped with pools large enough to accommodate such animals.

Our specimens represent the so-called Bottle-nosed Porpoise, (*Tursiops truncatus* Montagu), and were captured at Cape Hatteras, North Carolina, about 400 miles south of New York, on November 12, 1913.

The captive porpoises are very lively and keep swimming day and night, rising to blow usually with each circuit of the pool. Being kept in shallow water, they probably breathe oftener than they would in deep water. They often swim under water, belly up, like seals, but never lie upon the bottom or bask at the surface as the latter do. Visitors ask whether they ever rest—a question not easy to answer. If they do, it is apparently without cessation of forward motion. Nevertheless they are quieter at night when most of the lights are cut off, and do not indulge in boisterous play. For a time two of them habitually moved from left to right, while three took the opposite course, but this practice soon became less regular and is appar-

ently breaking up. Sometimes the speed is slow, but more often it is rather rapid. Occasionally they indulge in a bit of racing that makes high waves, the water surging up to the coping of the pool. A porpoise *speeding* around the pool can make a right-angled turn as quickly as a frightened fish, without lessening speed.

When being fed all regularity of movement is abandoned, and they rush in various directions to seize at the surface the fishes slowly thrown into the pool. This continues for some time after feeding, until all sunken scraps are gleaned from the bottom. All food is swallowed under water. Frequently a porpoise will play with a dead fish, thrusting its head clear of the water and throwing the fish from five to ten feet away, when it is recovered and thrown again. Such play may last half an hour, or until the fish is reduced to scraps too small to be thrown. It is not uncommon for two or three of them to be engaged in throwing fishes at the same time and the practice is becoming habitual.

Several times a day they indulge in very active play, darting with mock ferocity after each other, or leaping quite clear of the water and striking with heavy splashes. They often swim on their backs, with the jaws out of water, or on their sides repeatedly striking the surface with the head. When leaping a favorite trick is to throw the body around until the dorsal fin is forward, with a resulting splash that sends the spray quite out on the floor. A high leap by one of them is usually a signal that starts them all to leaping. Our fears that they might leap quite out of the pool were unfounded; they are clever enough to avoid the wall which surrounds them. Another game is played by going around the pool with short dives, each time striking the surface with the flat of the tail. When the pool is entirely full of water their play is livelier than when the water level is lowered. The increased depth gives them more confidence and they often turn complete forward and backward somersaults. The ordinary swimming motion of the tail is up and down, but, if playfully charged by a companion, the porpoise seems to make a spurt ahead by more or less side action of the tail. This is not easy to determine, however, and may be more apparent than real, as the water is too much dis-

turbed by high speed dashes for accurate observation. The animal undoubtedly relies upon its tail for propulsion, the flippers or pectoral fins being brought into action in making turning movements. Several of the porpoises have lately taken to swimming on their backs, and the movements of the flippers and tail at such times is easily seen as contrasted with the white under parts. In swimming on the back, however, there is considerable lateral action of the tail.

Frequently three or four of them will bunch together in the center of the pool, rolling and rubbing against each other in a ball-like mass suggestive of the tussling of puppies. This may at times mean that they are merely scratching, as the single porpoise kept in the Aquarium for two and a half months last summer frequently rubbed his sides or back against the back of a large sturgeon kept in the same pool. This injured porpoise indulged in no play and swam day and night in the same circle from right to left, but always fed freely.

There is considerable mobility of the neck of the porpoise, an animal lacking all outward appearance of a neck. The head can be turned down at an angle of about 45 degrees to the body, and can be turned as far sideways with equal readiness. These motions can be seen at feeding time and when the animals are tossing fishes.

There is no evidence that the porpoise can see out of water. In throwing a fish the head is often thrust well above the surface, but the animal seems to be always intent on its plaything, entirely disregarding the visitors leaning over the rail five or six feet away. While a fish thrown into the water is promptly seized, the porpoise pays no attention to a fish suspended by a thread two inches above the surface. If the eyes of porpoises and other whales were fitted for observation above the surface of the water, as are the eyes of seals, they might long ago have learned to use them in the same way.

Porpoises instantly recognize any change that may occur in connection with the water level of the pool. The entirely noiseless opening of a distant valve to lower the water, is apparent to them and may stop their play temporarily. A pool only thirty-seven feet in diameter does not of course afford space for the high activity of which the porpoise is capable. Never-

theless they often leap three feet or more clear of the surface, sometimes striking the water forcibly enough to throw spray thirty feet away and fifteen feet into the air. The visitor soon gets the impression that they enjoy life even in captivity and their keepers, while always vigilant as to their needs, have ceased to be concerned about their safety, regarding them as almost domesticated animals.

The naturally sociable and gregarious habit of porpoises is evidently not lessened by captiviy. Sometimes they seize each other by the back just behind the dorsal fin, but there are no tooth marks on any of them and it is probably done in play. The indications are that they are altogether amiable and inoffensive toward each other. The only species of porpoise destructive to its kind is the well-known "Killer" (*Orca gladiator*).

Our porpoises were observed mating in January, and again in March and April. It is possible that they will breed in captivity if their lives are not shortened by indoor life. The period of gestation is not known for any species of the whale order.

One of the five porpoises, put into the pool apparently uninjured, soon became deformed in the hinder portion of the body and cannot participate in the rough gambols indulged in by the others, keeping mainly to the outer circle of the pool. Its injuries are probably due to rough handling at the time of capture, as some of the porpoises were dragged away from the net with a rope tied around the tail. Its present appearance suggests two dislocations of the vertebrae back of the dorsal fin. This porpoise always swims slowly and is without doubt permanently crippled, yet it feeds as freely and oftens attempts to throw fishes as the others do.

The Bottle-nosed Porpoise (*Tursiops truncatus*) resembles *Delphinus delphis,* a species of porpoise or dolphin more abundant in the eastern Atlantic and in the Mediterranean than along our coast. It is somewhat larger and darker and has fewer but larger teeth, while the jaws present less of the beaked or "bottle-nosed" appearance of *Delphinus*. The latter is the dolphin known to the ancients, and has been caricatured by painters and sculptors since the very beginnings of art. The artists now have an opportunity to learn what the real dolphin looks like.

All porpoises and dolphins belong to the large family *Delphinidae,* of the order of whales, and there are about fifty different species. The names porpoise and dolphin are to some extent interchangeable; the former is, however, usually applied to the short-jawed kinds. The name "bottle-nose" is inapt, as the nostrils of all such animals are on top of the head and usually placed as far back as the eyes. The name dolphin is also applied to a fish (*Coryphaena*) celebrated for its changing colors.

Porpoises and dolphins are found in all seas, and there are strictly fresh-water species inhabiting the Amazon, Ganges and other rivers. The porpoise of the muddy Ganges is a small-eyed species that is practically blind, and lives upon crustacea gathered at the bottom of the river. The porpoise-dolphin family includes the little white whale or beluga of the Arctic Seas, two living specimens of which were once exhibited at the New York Aquarium for a month or more. The Aquarium has also had two other porpoises, *Delphinus* and *Legenorhynchus,* both of which were cast ashore too badly injured to live more than a few weeks.

The food of marine porpoises is chiefly fish and squid, for the capture of which their numerous small teeth are well fitted. At Hatteras they are known to feed largely on squeteague or weakfish. The fact that sand has been found in the stomachs of porpoises, indicates that they sometimes feed at the bottom. They are air-breathing, warm-blooded mammals, bearing a single young, which is nourished on milk. They are really small toothed whales, living entirely in the water and are altogether helpless on land. Two previous attempts were made to bring porpoises from Hatteras to the Aquarium. Instructions for their transportation were prepared in detail, but the plans were not carried out by those to whom the shipments were entrusted. In the first instance all the animals, eight in number, died en route, as they were unfortunately carried without water in the shipping tanks, and could not survive the journey without the cooling and supporting medium of water. The next attempt, in April, 1913 when the same blunder was made, gave only slightly better results. Although covered with wet burlap, four of the six porpoises shipped died between Hatteras and Norfolk,

Virginia. At the latter point the consignment was met by the Director of the Aquarium, who promptly filled the tank containing the two survivors with water. One of these animals died soon after reaching New York, but the other lived two and a half months, notwithstanding the fact that the heating it had undergone during the first stage of shipment resulted in injuries which eventually ended its career. While adult porpoises give no special signs of distress when carried dry, they become greatly heated and develop large blisters, which later become festering sores, extending through the blubber and into the flesh. Being adapted to a life in the water, to which they naturally radiate a great amount of heat, water is absolutely necessary for the control of the body temperature.

Believing that plenty of cool water would insure safety during transportation, the Director of the Aquarium went to Hatteras in November, 1913, to supervise personally the details of shipment, which, entrusted to others, had been disregarded. As far as the adult animals are concerned, the results of the trip have been satisfactory, but the five half-grown animals, brought at the same time, died soon after their arrival in New York. The adults, each about eight feet long, gave no trouble during shipment, while the young were exceedingly restless and continually bruised themselves by their struggles in the shipping tanks.

Porpoises are hot-blooded, blubber-covered mammals and give off so much heat that the water of the shipping tanks becomes actually warm, and must be replaced by cold water every five or six hours. Immediately after their capture at Hatteras, where they were brought to land with a large drag-seine, the porpoises were placed for twenty-four hours in a deep salt water pond just back of the ocean beach. Here they had an opportunity to recover somewhat from the fright of capture, and to rest in cool water. No chances whatever were taken in the matter of temperature. On the beach their natural warmth of body would no doubt have been greatly increased by the hot sunshine. The following day they were seined out of the pond and placed in the shipping tanks, which were then hoisted on board a schooner and at once filled with water. During the voyage through the fresh waters of Pamlico Sound and

the Great Dismal Swamp Canal, the water in the tanks was changed whenever it became warm. After reaching the New York steamer at Norfolk the cooling of the porpoise tanks en route was greatly simplified by the use of the steamer's salt-water hose.

The shipping of porpoises alive is therefore a simple matter. The adult animals readily stand transportation, while the young do not. If carried in long, narrow boxes large enough to accommodate them without rubbing, and if kept supplied with sufficient cold water to support and cover them, they can be handled easily enough. There is probably no reason why a porpoise, under such conditions, should not be carried in a tank many times the two-days' journey from Hatteras to New York, although on a journey by rail the changing of the water would be difficult and expensive. While its temperature could be controlled by the use of ice, the water carried without changing would be seriously fouled, for two or three days. The question of food could be disregarded for a few days without injury.

Our porpoises are heavy feeders, the five consuming about ninety pounds of fresh fish a day. This quantity of food has kept them in good condition, apparently without loss of weight. For several days after their arrival they would eat nothing, but at the end of a week they began to take live fishes and, after having once started to feed, it was not difficult to get them to take dead fish. A few days of hunger brought them around, as it does in the case of the newly captured seal or sea lion. Their principal food is herring and tomcod purchased in the markets. The live crabs thrown to them at various times were quickly seized and much tossed about, but were not eaten.

The keeping of porpoises in captivity has presented some difficulties with the water supply, their excrement constantly discoloring the water. The pool cannot be drained empty and cleaned, like those used for seals, as stranded, and consequently frightened, porpoises beat the ground with their tails so violently that they would be injured by the daily emptying of the pool. The water is now being kept fairly clear by carrying extra pipe lines to the pool and greatly increasing the flow of water. The pool is supplied with the brackish and rather impure water

pumped from New York Harbor, as it is not practicable to supply it with pure sea water from the Aquarium's large storage reservoir, on account of the fact that porpoises would rapidly discolor the stored sea-water which is so important to the health of the collection of marine fishes in the Aquarium. The necessity of keeping them in the water of the Harbor, and exhibiting them in a public exhibition room which has to be heated during the winter, makes it, of course, impossible to hold them under entirely favorable conditions, yet they are undoubtedly doing well. They could no doubt be kept for some time in fresh water, as is some times done with seals and sea lions, but they would eventually suffer from the lack of the salts contained in sea water. Porpoises, perhaps of this species, frequently enter the fresh waters of Pamlico Sound through the inlets southwest of Hatteras, and many species of marine porpoises make long journeys into the fresh waters of rivers.

The icy water pumped in winter from New York Harbor, generally lower than 40 degrees, Fahr., is much colder than sea-water at Hatteras, and requires to be warmed to about 55 degrees. In summer this will not, of course, be necessary.

Cape Hatteras is the only point in North America where a porpoise fishery has ever been regularly conducted, and where such animals can be taken near the shore and beached with drag seines. The bottle-nosed porpoise winters off our South Atlantic coast and is quite common in the vicinity of Cape Hatteras during the fall, winter and spring months. Schools of porpoises may be seen passing every day just outside the surf. They are taken with a net of extra heavy twine, about one thousand feet long, which is placed about two hundred yards outside the line of surf and parallel with it. At each end there is a boat in waiting, ready to carry the haul lines directly ashore as soon as a band of porpoises has passed between the net and the surf. After the lines have been carried ashore the porpoises are considered fairly secure, for they do not often attempt to cross the haul lines, and even when they do, can usually be frightened back by having someone shake each line continuously while it is being hauled in. It requires considerable time to bring the ends of the big seine to the beach, but even then some of the porpoises may get away by leaping over the net or

attempting to dive under it. The former can be prevented to some extent by sending a boat to the outer curve of the net, which serves to keep the animals from charging against it. Some of those that attempt to dive underneath become enmeshed and, being air breathers, are soon drowned. Thirty-three porpoises were beached in the haul of the seine which provided our specimens.

Although porpoises have been taken at Hatteras for two hundred years, the fishery has been conducted in a somewhat desultory manner, and with but little capital invested. The greatest number taken in a single year appears to have been fifteen hundred. Porpoises are valuable for their jaw oil, hides and body blubber, the value of each being in the order given. The oil derived from the jaws represents the greater part of the value, being worth ordinarily twenty dollars a gallon, refined. It is extracted from the broad posterior branches of the lower jaw, and is universally used for the lubrication of watches, clocks and similarly delicate mechanisms. An attempt was made at the Hatteras fishery to utilize the carcasses of these animals for fertilizer, but, as the location is isolated, the question of fuel for the furnace proved too serious and the project was abandoned.

The bottle-nosed porpoise (*Tursiops truncatus*) is the only species of porpoise that has ever been taken at the Hatteras fishery. Our eight-foot specimens represent the average size. A number of animals were measured in November, however, which exceeded nine feet in length. The greatest length for this species at Hatteras is twelve feet, but this is altogether unusual. Measurements and weights taken in November show that a porpoise five and a half feet long weighs 100 pounds; six feet, 160 pounds; seven feet, 200 pounds; and eight feet, 300 pounds.

The movement of porpoises along the great beach which extends in a general southwesterly direction from Cape Hatteras is usually close to the surf. The bands appear to move in both directions. Residents of Hatteras are of the opinion that the majority of those in the vicinity of Hatteras Inlet move to the eastward, turning south from the Cape, whence they gradually swing back to the mainland. They have not, however,

been followed away from the beach, and their winter movements are not known with certainty.

The roving bands of porpoises may number from a dozen to several hundred, and are present in that region from early in October to early in May, when the majority of them move northward. This is by far the commonest of the eight or nine species of porpoises found in summer along the North Atlantic coast of the United States. The species is one that is widely distributed, occurring in many parts of the North and South Atlantic and the Mediterranean, and may even be abundant at other Atlantic points in winter, as well as at Hatteras. It has also been recorded from the Indian Ocean and the vicinity of New Zealand.

The writer participated in the capture of sixty-three porpoises in a single day at Hatteras, and, as the animals were still passing, it is likely that the fishermen could have obtained many more by throwing out the net a third time. The two sexes occur in about equal members. An examination of fifty-one specimens on November 12 showed a preponderance of females, there being thirty-four females and seventeen males but there is much variation in this respect according to the season. In the spring all classes of young and old may be found in the same bands, while in the fall a band may consist chiefly of one class. Although there were no porpoises present having a length of much less than five feet, these were probably the nursing young, although their teeth had already appeared. All of the females examined were in milk, and the females killed were not only in milk but also contained young. Whether there were still smaller animals, which might have slipped between the meshes of the net, could not be ascertained, but the indications are that the porpoises five feet in length represented the only young then with the herds, and were still nursing.

Females containing young are found in every catch from October to May. As porpoises are not taken in summer, there is no information relative to their condition at that season. On April 30, 1914, a fœtus was found "nearly four feet long," while other females killed the same day contained none over eighteen inches long. The period during which the young are brought forth, evidently covers several months.

The appearance of the unborn young is well shown on plates 11 and 12.

According to the statements of the Hatteras fishermen the young porpoise nurses while the mother floats on her side; when very young it swims just ahead of the mother, and is raised to the surface by her each time she rises to breathe.

If our porpoises live long enough to breed in captivity, our knowledge of whales in general and porpoises in particular will be materially increased.

The specimens now in the Aquarium were presented on the beach at Hatteras, by Mr. Joseph K. Nye, of New Bedford, Mass., the proprietor of the fishery. They were transported at the expense of the New York Zoological Society.

The writer is indebted to Mr. Nye, and to Mr. W. H. Rollinson, manager of the fishery, for the statistics of the catch presented herewith.

STATISTICS OF THE HATTERAS PORPOISE FISHERY FROM 1907 TO 1914.

Year	*Catch*	*Year*	*Catch*
1907	70	1911	826
1908	591	1912	467
1909	1550	1913	400
1910	1278	1914	1073

FIG. 2. SEINING PORPOISES (*TURSIOPS TRUNCATUS*) AT CAPE HATTERAS FOR THE NEW YORK AQUARIUM

FIG. 3. A HAUL OF THE PORPOISE SEINE
Cape Hatteras, November 12, 1913.

Photo. by C. H. T.

FIG. 4. CAPTIVE PORPOISES (*TURSIOPS TRUNCATUS*) DISPORTING IN A POND AT HATTERAS

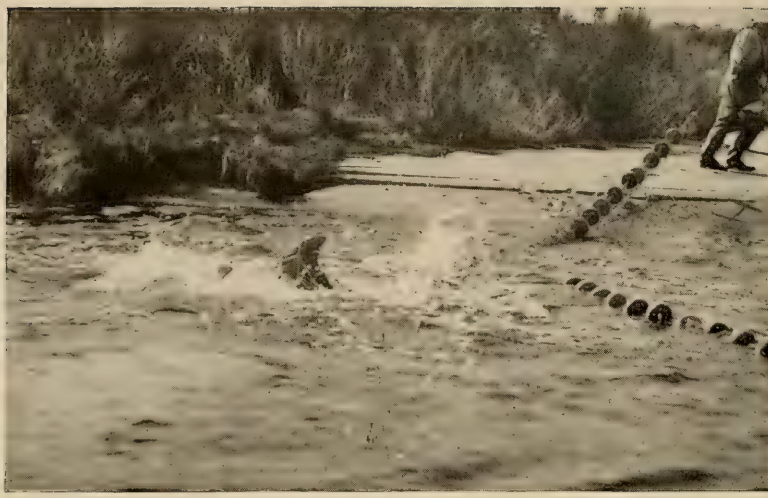

FIG. 5. RECAPTURING THE PORPOISES IN THE SALT-WATER POND

FIG. 6. A DECK LOAD OF PORPOISE TANKS: DISMAL SWAMP CANAL

FIG. 7. PORPOISES IN THE NEW YORK AQUARIUM
The pool is 37 feet in diameter and 7 feet deep.

FIG. 8. TURSIOPS TRUNCATUS

FIG. 9. TURSIOPS TRUNCATUS

FIG. 10. TURSIOPS TRUNCATUS

FIG. 11. FOETAL PORPOISE (*TURSIOPS TRUNCATUS*) 15 INCHES LONG
Hatteras, November 12, 1913.

FIG. 12. FOETAL PORPOISE (*TURSIOPS TRUNCATUS*) 12½ INCHES LONG
Hatteras, November 12, 1913.

FIG. 13. HEAD OF TURSIOPS TRUNCATUS
(Sand should have been wiped off.)

FIG. 14. SKULL OF TURSIOPS TRUNCATUS, HATTERAS, N. C.

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REVIEW OF THE GENUS *GENNAEUS*

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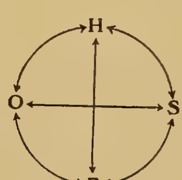
PART I.

Evolution as a phenomenon is beyond dispute. The exact methods of evolution are only partly clear. We have so far failed to discern many of the ways and means by which the organisms of our day have acquired their adaptations, have differentiated their tissues, or have survived the competition of past generations. One thing is certain: no single theory will suffice to account for the evolution of life in general, nor even for a single organ of any individual. If careful study of the subject has taught us nothing else, it has constrained us to believe in multiple causes; in an eternal plexus of actions and reactions. And it is as impossible to believe that any one character subserves only a single function throughout the life of an individual, as that its inception in past time—whether gradual or sudden—and its development, was brought about solely by the action of any isolated factor.

I wish that every worker along the lines of evolutionary research would pin to his desk, place in his watch or strive always to keep vividly in both conscious and subconscious thought some such symbol of the eternal interaction of factors as Prof. Henry F. Osborn has given us.[1]



Heredity
Ontogeny
Environment
Selection

With such a "wheel of life," both controlling and stimulating, there would be less swinging of the pendulum to extremes,

[1] Science. XXVII. 1908, p. 14; and Jour. Acad. Nat. Sci. Phila. XV. 1912, p. 298.

less striving to make every fact, every color, every hybrid, every tropism, fit some pet theory. There would be less arbitrary refutation, more leniency in perceiving the modicum of truth which may lie at the bottom of the most unpromising theory. This is the principal thought which the study of the family of pheasants has aroused; the realization of the plexus of factors dominating or indirectly affecting the evolution of the race and the development of the individual.

Part II.

The name *Euplocomus* was established by Temminck eighty-four years ago (1830), and has been expanded and maintained by many excellent authorities since that date. Today it is generally admitted to be a compound group and has been divided into as many as five genera. These are *Gennaeus, Hierophasis, Diardigallus, Lophura* and *Acomus.* Any careful study of the comparative claims of this quintet to full recognition, emphasizes most profoundly the wholly artificial character of any linear classification, and although the discussion of this is not the main thesis of the paper, yet it is interesting to consider it briefly; especially as I wish to illustrate the thought presented in Part I.

In recent years there has been a redundancy of discussion as to whether species owe more to continuous or to discontinuous variation, a better term for the latter being saltation. For several reasons I purposely avoid using the term mutation in this brief paper. When I began my studies of the pheasants I was consciously or subconsciously prejudiced against the "mutation theory," chiefly perhaps because it appeared that altogether too much was claimed for it, and if the most convincing proof of any given mutation required several generations, there was slight chance of demonstrating it among birds save in a few isolated, favorable instances. But the more I observed such species as the Golden and Amherst Pheasants (*Chrysolophus pictus* and *amherstiae*), the color relations in both sexes, and the results of hybridism, the more necessary some such phenomenon as saltation appeared to be, in these particular instances. That saltations occur in this family I consider satisfactorily proved by the Black-throated Golden

Pheasant and the Black-shouldered Peafowl. I am now of the opinion that both forms of variation have been operative in the origin of wild forms and that the difference between them is pronounced if not profound. As an example of continuous variation I would cite the entire genus *Phasianus* (as I have recently restricted that group[1]). The supergenus *Euplocamus* well illustrates in its generic divisions what seem to be saltations.

The moment one attempts to define genera and subgenera in such a homogeneous group of organisms as the pheasants, one becomes aware of the personal equation. In the division into subfamilies I have sought to eliminate this by making use of the only consistent character which I could discover, namely, the sequence of moult of the tail feathers. With the impossibility of appeal to osteological or other fundamental characters, we are compelled to fall back upon purely superficial distinctions. Where the resemblances are as numerous as the differences, and yet when convenience in discussing the various groups demands some taxonomic isolation, however artificial, one again instinctively begins a search for something which will help to eliminate the personal element. This personal equation is in very truth affected by H and O and E and S, and its variation is enormous. So it behooves one to attempt to base one's taxonomic belief on something more stable and more acceptable to foreign fellow ornithologists, than the mere *credo* derived from the multitudinous mental forces, both true and erroneous, resulting from American education and American environment.

Looking over the groups of pheasants, in number about a score, it seems to me that there is a criterion which may be adopted for differentiation into genera. Like the sequence of tail moult it is a character which must be consistently applied throughout the family, and, also like that character, it is abstractly doubtless of no value, at least in many other families of birds. But if it helps in deciding a few cases which seem so evenly balanced that their position might rest upon the turn of a coin, it will be worth while. This factor which throughout my studies has gained in cumulative significance, is that, *no two species of any one genus occupy the same geographic area.* This

[1] Preliminary Pheasant Studies, Zoologica, I. No. 15, 1914, pp. 283-284.

is true of so many groups that with the removal of *reevesi* and *soemmerringii* from *Phasianus* it holds good throughout the pheasants. And now in considering the status of the euplocamine pheasants, we are able, by applying it, to make our division rest on something beside wholly tentative and altogether artificial separations.

For in this case we are dealing with generic relationships of so subtle and complex a nature that a satisfactory decision on mere color and pattern and crest characters seems impossible. By invoking unlimited additional taxonomic castes or by employing a classification imagined in the three planes of space, the whole matter is at once simplified. For example, few would object to this scheme:

Subfamily *Phasianinae.*

Supergenus *Euplocamus.*

Genus *Gennaeus.*

Subgenus *Hierophasis.*

Then again an additional division, called perhaps Section, should be instituted to include the Fire-backed Pheasants, *Diardigallus, Lophura* and *Acomus,* occupying a distinct niche between the subfamily and supergenus. And so on.

The fineness of the distinction is well shown by the following groupings:
Classification by

Fiery back	Gennaeus + Hierophasis Diardigallus + Lophura + Acomus
Number of rectrices	Gennaeus + Hierophasis + Diardigallus + Lophura Acomus
Color of facial wattles	Gennaeus + Hierophasis + Diardigallus Lophura + Acomus

Taking into consideration the distributional factor, we find (as in the utilization of the tail-moult character) that one of

the most generally accepted classifications remains undisturbed. My new point of view merely provides a more logical, consistent basis. With its accompanying rough summary of geographic distribution, I suggest the following:

Genus *Gennaeus* Himalayan Terai, Assam, Burma, South China, Formosa, Annam, Hainan.

Subgenera *Gennaeus*

Hierophasis

Genus *Lophura* Siam, Malay Peninsula, Sumatra, Borneo.

Subgenera *Diardigallus*

Lophura

Genus *Acomus* South Malay Peninsula, Sumatra, Borneo.

If *edwardsi* proves to occupy the same territory in general with some more typical *Gennaeus,* I should at once remove it, together with its close relation *swinhoii,* and give *Hierophasis* full generic recognition. This has as many characters to warrant it as militate against it. The final settlement of its position should always be consistent with the chief use of taxonomy; clarity of relationship combined with the greatest use to the widest circle of workers.

The two points which I wish to emphasize are, first, the existence of two distinct types of specific relation in the family of Pheasants; and second, the possible correlation of generic distinction with geographic isolation.

Part III.

For many reasons the genus *Gennaeus* is the most interesting in the family *Phasianidae,* and especially because of the puzzling nature of many of the forms. The birds of this group are commonly called Kaleege and Silver Pheasants. It will result in least confusion and comply with the custom of more ornithologists if the former be used as a common generic term.

In the field, my experience with these birds extends from the haunts of *albocristatus* in Kashmir to *nycthemerus* in Fok-

ien, and from *horsfieldi* in Upper Burma to *lineatus* in Lower Burma. I collected or made notes upon many of the forms, not only of adults in full plumage but of moulting birds and those in immature dress. Forearmed with the details of what had already been published on the subject, I was able to search more intelligently and with more direct design than would otherwise have been the case. More than this, however, was the aid given by the English sportsmen in Burma, who in some cases furnished me with data and specimens which were of the greatest help. In several instances these were the very men who had collected the original types, so their assistance cannot be overestimated.

In the study of museum specimens I was not so fortunate. The Indian Museum in Calcutta was open to me and there I found and studied a very good collection, including the types of *andersoni, melanonotus* and several other unique pheasants. The museums of Paris and Berlin also possess interesting specimens but Oates' collection of *Gennaeus* at the British Museum with over one hundred and sixty specimens and at least fourteen types was not available for study in the summer of 1912. Now that two years have passed and no report has been made upon this collection I offer a preliminary summary of my study of this group, depending upon Oates' published descriptions of his supposed species. I am quite sure that any future investigations of the British Museum collection will in no way affect the general results I have reached.

I feel all the more certain in stating this belief because I find myself in almost perfect agreement with Prof. Allessandro Ghigi. It is most significant that while the conclusions of this Italian ornithologist were reached by a study of the phenomena of experimental hybridism and mine by independent observation of wild shot individuals, our results differ only in very minor details. His paper to which I refer is *Ricerche di Sistematica Sperimentale sul genere Gennaeus Wagler*[1], forming the most thorough and masterly contribution to the subject which has yet appeared. Owing to the excellent keys and descriptions which he presents, I omit their duplication in this paper, giving only my general studies and results.

[1] Memoria R. Accademia delle Scienze dell' Istituto di Bologna, 1909.

The tangle which has arisen about this genus centers in Burma, and, in a word, the whole question resolves itself into whether the numerous forms which have been described from that country are valid species and subspecies or only hybrids, the naming of which might be continued indefinitely without benefit to the understanding of the genus.

In order even to begin to clear up the problem it is necessary to have a definite starting point and for this I have chosen the Lineated Kaleege (*G. lineatus*). Geographically and pigmentally this species occupies a central position. From the point of view of color and pattern it is the most generalized of all the species, while its uniformity over almost its entire range leaves no doubt as to its right to true specific recognition. The black and white on the upper plumage is broken up into fine vermiculation, the two being about equal in extent, the very specialized color extremes of solid white or black being thus lacking. A further hint of its more generalized type is the superficial resemblance which it bears to the nearly related tropical genera, *Acomus* and *Diardigallus*.

From this point even a superficial survey of the genus shows two, and very probably three main lines of divergence. To the north and westward along the Himalayan terai extends a succession of dark feathered birds, in which the whites are reduced or concentrated on certain limited portions of the plumage. From east to west these are *horsfieldi, melanonotus, leucomelanus* and *albocristatus.* In all four there is a small amount of variation, but, *inter se,* no actual crossing has ever been recorded in a wild state, nor did most careful search and inquiry on my part reveal a single instance. I have taken this up in detail in my monograph and there is no need to reproduce it here.

It is important to note that the distinctions between the four Himalayan Kaleege Pheasants have been shown by Ghigi to behave in experimental crossing exactly as though they had been derived by mutation, not blending as do the characters of the Burmese birds.

To the northeast of *lineatus* we find a second line of *Gennaeus* Pheasants, of which the most widely distributed is *nycthe-*

merus, the Silver Kaleege. On the island of Hainan is an offshoot from this, *whiteheadi,* quite close to the typical species, but of course worthy of specific recognition on account of its complete geographic isolation.

A third line, quite distinct from *lineatus,* is found to the southeast in Annam. This is *edwardsi* whose connection with *lineatus* at least as a direct offshoot is at present somewhat obscure. Although it is known only from a few specimens from Annam, yet its rather close relationship with *swinhoii* is of great interest. The latter inhabits the island of Formosa, and with its tropical, *Lophura*-like brilliance of color differs much from *nycthemerus,* the only species at present inhabiting southeast China. *Edwardsi,* however, shows a very probable linking relationship, less specialized, and much nearer the supposed center or origin.

After carefully going over all the data available, I cannot see that there are any other species worthy of recognition on grounds similar to the nine Kaleege I have mentioned.

Centering our attention again on Burma and the adjacent Chinese states, we find that most of the country is occupied by three species, *lineatus, horsfieldi* and *nycthemerus.* Now in all the genera of pheasants there is, as far as I know, no case of two congeneric species occupying the same territory. This was not true as long as *reevesi* and *soemmerringii* were included in *Phasianus,* a very obviously erroneous association, which I have attempted to better. We find that in addition to the nine *Gennaeus* I have already mentioned, there have been described under binomial names, no fewer than twenty-six forms. Almost without exception these are all found within the range of one or the other of the three above mentioned, widely-distributed species, and not only this but they occur along the borders where the three approach one another. After studying these forms from every point of view possible, there is no doubt whatever in my mind but that all are feral hybrids. In some way after the three main types of Kaleege became differentiated, they approached one another again, working along the narrow, intersecting valleys of Central and Upper Burma, where cross-breeding took place, apparently as freely as it does in captivity. The

English ornithologist, Mr. Eugene W. Oates, toward the end of his life, became interested in these Burmese Kaleege and gathered all the specimens possible. He had no belief in the hybridizing of these birds, and so strong was this attitude, that the naming of new forms became an obsession with him. He grew intolerant of criticism and welcomed neither argument nor proof, however convincing, that any of his species were other than normally evolved forms. But aside from this, his work was sincere, and however limited his ability to view the subject from more than one angle, he at least labored to gather together a splendid collection, and we are greatly indebted to him for giving this unusual phenomenon such prominence.

Of the twenty-six so-called species, Oates is responsible for nineteen, a goodly percentage of which were based on single specimens.

The conclusions which Ghigi draws from his experiments seem important enough to quote in full, both the original and the translation.

"Returning to the birds forming the subject of the present study, if we proceed to examine *G. leucomelanus* and *G. horsfieldi,* or rather this last one and *G. lineatus,* we see that they differ in a complexity of characters, which, in the hybrids are so arranged as to produce an intermediate form, or else, they transmit them in a different association from that existing in the progenital species. Granted that these intermediate forms or with the characters associated in a different manner, may be constant in their descent, it is clear that two distinct species have the power to give origin to a new form by crossing.

"If, however, we consider *G. leucomelanus* and *G. muthura* or else the first and *G. albocristatus,* it is clear that from hybrids between them, we are not able to obtain new forms, as the difference consists in each case of only one pair of characters, antagonistic and unresolvable. The hybrids of the first pair will have the white fringe on the rump or will not be provided with it; those from the second pair will have the crest black or will have it white; they will belong then either to one or the other species, and even if they should be intermediate in the sense of having the white fringes not as large as in *leucomelanus,* or the

crest not as light as in *albocristatus,* it is plain, that they cannot give origin to any new subspecies, because from what I have shown in my researches, and from what is established in the abundant hybridological literature of today, these hybrids, which differ in only two antagonistic characters, give place in successive generations to the separation of such characters according to the formula of Mendel, returning thence to the pure progenital species."[1]

After finding and studying the Himalayan Kaleege, I later visited Burma and there in the south first met with *lineatus.* My next studies took me to Mandalay, eastward beyond Maymyo, and northward toward the Ruby Mines District and Bhamo. I then spent considerable time in the Myitkyina District far up the Irrawaddy, and among the Shan Mountains to the east and south, to beyond the Yunnan border. Here, thanks to the exact details given me by Major Nisbett, I was able to collect and observe a number of the forms at the very localities where the types were collected.

From this very limited locality six forms of *Gennaeus* had been recorded. Of these I found no perfectly typical specimens, but pheasants which approximated four, besides a fifth which was not supposed to occur here. In addition I collected birds, which if judged by the characters used in separating the already named forms, would supply at least four additional species.

[1] Riportandomi agli uccelli che formano oggetto del presente studio, se noi prendiamo ad esaminare il *G. leucomelanus* ed il *G. horsfieldi,* oppure quest'ultimo ed il *G, lineatus* rileviamo che essi differiscono per un complesso di caratteri i quali, negl'ibridi, si fondono in maniera da produrre una forma intermedia, oppure si trasmettono in associazione diversa da quella esistente nelle specie progenitrici. Dato che queste forme intermedie od a caratteri diversamente associati, siano stabili nella loro discendenza, è chiaro che a due specie distinte compete la facolta di dare origine per incrocio a nuove forme.

Se invece consideriamo il *G. leucomelanos* ed il *G. muthura,* oppure il primo ed il *G. albocristatus,* è chiaro che dalle unioni provocate fra di loro non si possono ottenere nuove forme, in quanto la differenza consiste per ciascun caso in una sola coppia di caratteri antagonisti ed indecomponibili. Gl'ibridi della prima coppia avranno le frange bianche sul groppone o ne saranno sprovvisti; quelli della seconda coppia avranno il ciuffo nero o lo avranno biancastro: apparterranno dunque nettamente o all'una od all'altra specie, e quand'anche essi fossero intermedi nel senso di avere le frange bianche non cosi ampie come nel *leucomelanus* od il ciuffo non così chiaro come nell'*albocristatus,* è evidente che essi non possono dare origine ad alcuna nuova sottospecie, perchè da quanto ho esposto nelle mie ricerche, e da quanto si rileva nella numerosa letteratura ibridologica odierna, questi ibridi i quali differiscono per due soli caratteri antagonisti, danno luogo nelle generazioni successive alla separazione di tali caratteri secondo la formula mendeliana, ritornando quindi alle specie progenitrici pure.

The species supposed to inhabit this region are the following:

1. *affinis* (1 male from the River Namli; two thousand feet; east of Myitkyina).

2. *granti* (1 male from Puntum; six thousand feet; eight miles east of Sadon).

3. *nisbetti* (An imperfect male from Mt. Kachin; twenty-five hundred feet; fives miles east of Sadon).

4. *cliffordi* (The district in general).

5. *batemani* (The district in general).

6. *horsfieldi* (The district in general).

At the locality from which *affinis* is recorded, the lower River Namli, I found only *horsfieldi,* which was dominant and almost typical, and a vermiculated bird associated with it which closely resembled the description of *obscurus,* but differed from it as much as do the most nearly related named species. The two forms were living in close association, the first flock containing three birds, all males, two of which were *horsfieldi.* In fact this was about the numerical percentage of the latter in this vicinity. On two occasions I saw a distinctly lighter bird in company with *horsfieldi* but I failed to secure it. My next stop was at Pungatong, some twenty miles farther east, at an elevation of about four thousand feet. Here I located a flock of eleven Kaleege, or what was probably two families of four and five respectively, and two single cock birds. Each afternoon these would unite and take the same route to water, down a gently sloping hillside covered with light forest, across the trail and on down to the stream at the bottom of a rather steep ravine. I watched these birds carefully day after day until I could actually recognize the individuals, in spite of the fact that they were usually well looked after by a mob of Laughing Thrushes. Then I began shooting and secured no fewer than eight birds out of the eleven. This comprised all of one family of two parents and two almost full-grown young males in first-year plumage; the adult male parent of the second family with a young female of the year, and both of the solitary cock birds—

fully adult. The tale of individuals was as follows, using Oates' nomenclature:

Family number one:

I. Adult male. On the whole, this bird resembled *horsfieldi,* but it had the narrow rump fringe and lengthened tail of *batemani,* the intense blue, non-vermiculated rump of *mearsi,* and in addition the scarlet legs and feet of *nisbetti.* The central tail-feathers were sparingly but strongly vermiculated with white for most of their length, the terminal fifth being clear black.

2. Adult female. This bird which was constantly associated with the above cock, (in fact I secured both with one shot) was not distinguishable from females of *horsfieldi,* except for the somewhat longer tail. Well-grown as were the two young birds, more than once I saw this female allow them to take food away from her, and from this and other actions, besides the constant association of the four birds before they joined the others for the afternoon's descent to water, there is not the slightest doubt in my mind that this was a a single family of Kaleege.

3. First-year male. Typical *horsfieldi* as found in Assam, with tail of normal length, but with the basal vermiculation on the inner rectrices visible for a half-inch beyond the upper tail-coverts.

4. First-year male. Between *obscurus* and *davisoni,* with characters of each form.

The two following birds I judged to be parent and young:

5. Adult male. Superficially close to *lineatus* with somewhat coarser vermiculations, and with the outer webs of the outer tail-feathers almost unmarked black as in *andersoni....* The central tail-feathers were vermiculated throughout, with no hint of a pure white area. There was no trace of a rump fringe.

6. First-year female. This bird does not correspond to the description of the females of any form. The gen-

eral color above was olive brown, very minutely vermiculated with black, except along the margins of the feathers, where the black dying out, the pure olive brown showed paler and clearer. The primaries were brownish black, densely mottled with grayish-brown on the outer webs. The secondaries were similar, with the color of the outer webs changing into that of the coverts and remainder of the upper plumage.

The chin and throat were white, tinged with brown along the margins. On the under parts the light color persisted as a well-defined buffy shaft-stripe. The rest of the feather was clear olive-brown, with but little mottling except on the center of the lower breast and abdomen, where the entire feather was irregularly blackened, especially along the enlarged shaft-stripe. The under tail-coverts were the blackest of all the contour feathers, most of them showing brown only along the margin. The outer and median tail-feathers were chestnut, obscurely but coarsely mottled with black. Toward the central pairs the chestnut changed to a brown, and the darker color became a coarse vermiculation, the lines irregular and lying obliquely to the shaft.

The facial skin was scarlet; the irides light hazel; legs and feet pale neutral. leaden gray.
I have gone into this in detail to show what variation I found among the females of this group of Pheasants.

7. Adult male. One of the solitary males was *horsfieldi* in length of tail and general markings, except that there was more vermiculation on the central tail-feathers than I have seen in any bird from Assam, and the inner wing-coverts were very strongly margined with white.

8. Adult male. The second male I shot on sight, and at such close range that I nearly blew it to pieces. At first glance it seemed to be a Silver Pheasant (*nycthemerus*) and stood out sharply from all its companions on both the occasions when I watched it work-

ing down hill. The second time I had my gun and secured it at once. It proved to be a very dark representative of what has been called *ripponi*, but differing in having greenish, instead of scarlet legs and feet.

All this astounding variety of Kaleege I found within two miles of the dâk bungalow at Pungatong, associating together, and, as I have said, with satisfactory evidence of being in families. Even if the birds were of no immediate relationship however, the fact of their remarkable variation is none the less indicative of hybridism. This is typical of what I found to exist in other parts of Burma. The Arrakan country and Annam I did not visit and hence I cannot speak at first hand with regard to the birds which inhabit those regions.

All the specimens which I gathered in northern Burma tend to exhibit this individual variation and blending of characters, and in all my observations there is nothing to show any pronounced uniformity in the forms I have mentioned. But while thus being compelled to consider these as unworthy of specific validity, there is an interesting phase of the subject in regard to certain of the other forms. Some of these Pheasants which apparently owe their peculiar color and pattern to the crossing of two feral species, seem to have found more or less isolated regions where they have become established. They thus do not transgress the rule of each species being confined to its individual range. It would seem that a saltation of sorts must have entered into these cases, to fix the evanescent hybridic characters, but this we can at present only surmise. It is difficult to know exactly how to treat these, but inasmuch as they have usurped a comparatively large extent of country, and within its limits seem to breed fairly true, I see no reason why, tentatively at least, they should not be recognized, their mode of origin being kept always in mind. As far as I know, up to the present time, there has never been intentional recognition of wild hybrids as species, but if any of the four forms which I mention ultimately prove to breed true over a definite extent of country,

I see no reason why we should not distinguish them by a distinct name. They would assuredly have as much right to one as *Carpodacus mutans,* the House Finch which was introduced less than forty years ago into the Hawaiian Islands by man, and which has received this new specific name[1] because its colors are now yellow or orange instead of crimson.

These Kaleege are four in number, *sharpei, ripponi, oatesi* and *cuvieri*.... The first two are perhaps most worthy of inclusion in the list of tentative hybrid species, and until we learn more of the range and variation of the remaining two, I shall give them the benefit of the doubt, and a place in this category. *G. williamsi* is a form quite widely distributed within the limits of *horsfieldi* between the Chin Mountains and the Irrawaddy, and farther to the west, but the few specimens I have seen were too variable to consider them even tentatively as other than fairly homogeneous hybrids.

I shall take up the four in order.

GENNAEUS SHARPEI.

Lineatus is found normally from sea-level up to a height of seventeen hundred and rarely two thousand feet, almost never higher, although I have one pair of these birds, almost typical, from Thandung, Toungoo, at forty-three hundred feet. Its range includes much of central Lower Burma on both banks of the Irrawaddy, as far east as 99° East Longitude. Well within this area and throughout a north and south distance of more than four hundred and twenty miles, specimens of the pheasant named *sharpei* have been taken. Usually the points of capture have been at considerable elevations, none lower than two thousand feet and ranging upward to six thousand. So it seems that, quite within the range of one of the parent species, a subordinate form has gained a foothold and, produced by the crossing of *lineatus* probably with *nycthemerus,* has by reason of a consistantly inhabited, higher elevation, been able to establish itself, and to extend in a considerable direction north and south.

Ghigi says in regard to *sharpei,* the translation being given as literally as possible: "We have seen how *G. sharpei* differs from *lineatus* in the fact that the upper parts rather than

[1] Grinnell, The Auk, XXIX, 1912, p. 24.

thinly and finely striped with white are over-run by a few large white-stripes; in the same manner as we have seen in the complex hybrids Nos. 47-49, which have ½ of *lineatus*, ⅜ of *muthura* and ⅛ only of *nycthemerus*. We might believe that in this series the character of *lineatus* might dominate, because represented by one-half, and because the two sexes of this species have taken part in its genealogy. We might also expect that the ⅜ of *muthura* would dominate over the single ⅛ of *nycthemerus* and have the effect of rendering the series darker. Instead the ⅛ *nycthemerus* dominates in a way to cause the contraction of the bands and shows how small a quantity of blood of this last may be sufficient to originate, by crossing with *lineatus*, a form identical with *sharpei*."

Gennaeus ripponi.

To this form should be joined *jonesi*, as the two are indistinguishable from the published descriptions. I knew that *ripponi* was supposed to cover considerable territory in Yunnan and the Shan country, and indeed I found the birds in western Yunnan and as I have related, a very closely pigmented individual in northeastern Burma. Not, however, until I had access to an unexpected and unusually large amount of material was its wide distribution proved beyond doubt. For a year or more a Chinaman had assiduously collected Silver Kaleege Pheasants in various parts of Yunnan and the Northern Shan States, and when he had gathered six large bales, he boxed them up, labelled them "ducks' feathers" and shipped them via Bhamo to Rangoon, en route to the milliners of Europe. But the custom officials at Rangoon, having had previous experience with Chinamen, investigated and in place of the feathers of domestic ducks, found hundreds of skins of Silver Kaleege, with a scattering of Lady Amherst and Burmese Bar-tailed Pheasants. The bales were promptly confiscated and condemned, and at the moment when awaiting destruction I was fortunate enough to come across the great mass of skins. I began at once to set official machinery in motion and with the help of a very amiable collector of Customs and Dr. Annandale of the Indian Museum, the entire lot was turned over to me. I spent considerable time studying the fragments, and later the best skins were picked out and sent to me.

I found that about twenty-five per cent. were pure *nycthemerus* while sixty per cent. were equally typical *ripponi,* the remaining fifteen per cent. showing intermediate grades between the two. Later I compared this great lot with several *ripponi* skins and found them almost identical, though fluctuating slightly in the direction of whiter *nycthemerus* or with the blacker shades of the so-called *rufipes.* With this evidence I do not hesitate to record this form as very probably hybrid in origin, but which in some way has at present become sufficiently distributed and established to warrant a sub-specific designation.

Ghigi says: "Taking *G. nycthemerus* as a point of departure we find among my hybrids, forms which differ from it to the same extent as *G. jonesi* (*ripponi*) and *G. rufipes.* The males (*nychthemerus* x *muthura*) x *nycthemerus,* correspond exactly in their upper parts to the first of the two species now cited."

Gennaeus cuvieri and *oatesi.*

The status of these two forms rests upon different evidence. Both have been obtained from the region west of the range of *lineatus* and south of *horsfieldi*; *cuvieri* from the moutains of North Arrakan and *oatesi,* farther south at about 18° North Latitude. About a dozen specimens of *cuvieri* have been taken, the first named by Temminck in 1820, while of *oatesi* only two or three are known, collected since 1893. The fact that these birds occur actually beyond the range of any other species and removed from any contiguous borders of the haunts of other Kaleege, is sufficient reason at least for giving them special mention, whether or not future exploration will extend the ranges of either *lineatus* or *horsfieldi* to include the haunts of these forms. Combined with the fine vermiculation of the upper plumage of *lineatus,* both add the white rump fringe of *horsfieldi,* so that no matter what their present status, there is little doubt as to their origin. I refrain from giving them trinomials, as no actual gradation has been discovered between them and either of the other species.

In conclusion, the Kaleege Pheasants forming the genus *Gennaeus,* seem to me to warrant the following disposition:

FULL SPECIES.

lineatus
horsfieldi
melanonotus
leucomelanus
albocristatus
nycthemerus nycthemerus
whiteheadi
edwardsi
swinhoii

SPECIES TENTATIVELY ADMITTED.

sharpei
nycthemerus ripponi
cuvieri
oatesi

HYBRIDS.

affinis
andersoni
annamensis
assimilis
atlayi
batemani
beli
cliffordi
davisoni
elegans
granti
haringtoni
jonesi = *ripponi.*
macdonaldi
mearsi
nisbetti
obscurus
ommansyi
prendergasti
rufipes
wickhami
williamsi

SUMMARY OF NAMED HYBRID *GENNAEUS.*

affinis Oates.

Ann. Mag. Nat. His. (7) XI. 1903, p. 231.
Single male killed by Major Nisbett, river Namli, east of Myitkyina.

andersoni Elliot.

Proc. Zool. Soc. London, 1871, p. 137.
Type in Indian Museum, Calcutta.
Several specimens; Anderson in Yunnan; Rippon at Warar Bun, 6,000 feet, in Kachin Mountains, 30 miles east of Bhamo.

annamensis Grant.

Bull. Brit. Orn. Club, XIX. 1907, p. 13.
Type in British Museum.
Three specimens; Vassal, Bali region, interior of Annam.

assimilis Oates.

Ann. Mag. Nat. His. (7) XIV. 1904, p. 286.
Types in Oates Collection, British Museum.
Six specimens, Ruby Mines District.

atlayi Oates.

Ann. Mag. Nat. His. (8) V. 1910, p. 162.
Types in Oates Collection, British Museum.
Seven specimens, Atlay, Ruby Mines District.

batemani Oates.

Journ. Bombay Nat. His. Soc. XVII. 1906, p. 11.
Types in Oates Collection, British Museum.
Eight specimens, Districts of Katha, Myitkyina and Bhamo.

beli Oustalet.

Bull. Mus. Nat. His. Paris, 1898, p. 258.
Types in Paris Museum.
Several specimens; Bel, Eastern Annam between Hué and the mountains.

cliffordi Oates.

Ann. Mag. Nat. His. (7) XIV. 1904, p. 286.
Types in Oates Collection, British Museum.
Six specimens; Myitkyina Dist., east of Irrawaddy.

davisoni Grant.

Cat. Birds British Museum, XXII. 1893, p. 304.
Type male in British Museum; type female in Oates Collection, British Museum.
About ten specimens, vicinity of Bhamo and in Yunnan.

elegans

Listed in Oates Collection.

granti Oates.

Ann. Mag. Nat. His. (8) V. 1910, p. 163.
Type in British Museum.
Single male; Nisbett, Puntum, east of Sadon.

haringtoni Oates.

Ann. Mag. Nat. His. (8) V. 1910, p. 162.
Types in Oates Collection, British Museum.
Single pair; Harington, Nilum Kha, Bhamo District.

jonesi Oates (=ripponi).

Ibis, 1903, p. 97.
Types in British Museum.
Distribution same as *ripponi.*

macdonaldi Oates.

Journ. Bombay Nat. His. Soc. XVII. 1906, p. 10.
Type male in Oates Collection, British Museum.
Specimens from Chin Mountains, from Mt. Victoria to Fort White.

mearsi Oates.

Ann. Mag. Nat. His. (8) V. 1910, p. 164.
Type male in Oates Collection, British Museum.
Several; Mears, from Sylhet; Bateman from Kamaing, Myitkyina District; also North Khasi Hills, Manipur, Tippera, and Goalpara in Assam.

nisbetti Oates.

Ibis, 1903, p. 99.
Type male in British Museum.
Incomplete skin of male; Nisbett, five miles east of Sadon, 2,500 feet.

obscurus Oates.

Ann. Mag. Nat. His. (7) XIV. 1904, p. 283.
Type female in Oates Collection, British Museum.
Specimens from Katha District.

ommansyi

Listed in Oates Collection.

prendergasti Oates.

Jour. Bombay Nat. His. Soc. XVII. 1906, p. 10.
Specimens from North Arracan.

rufipes Oates.

Manual Game Birds India, Part I. 1898, p. 362.
Specimens from Ruby Mines District in the vicinity of Mogok.

wickhami Oates.

Manual Game Birds India, Part II. 1899, p. 495.
Type female in Oates Collection, British Museum.
Specimens from the Chin Mountains.

williamsi Oates.

Manual Game Birds India, Part I. 1898, p. 342.
Over thirty specimens in Oates Collection. Between Chin Mountains and the Irrawaddy. Williams, from Kalewa; others at Chindwin, near Wuntho.

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NOTES ON COSTA RICAN BIRDS

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Part I.—Introduction.

After a nine days' journey on the United Fruit Company's steamer "Calamares," the writer, accompanied by T. Donald Carter as assistant, arrived at Port Limon, Costa Rica, on March 30, 1914. Our object was the gathering of living specimens for the collections of the New York Zoological Society, and when, after a stay of six weeks, we re-embarked on the "Calamares" with something over three hundred creatures, embracing all of the vertebrate classes, in our care, we felt that our efforts had not been in vain.

There was some delay in entering our luggage and it was only after a wait of several days, entailing a trip to the lovely capital city, San Josê, that this was finally accomplished. We were then free to repair to our proposed collecting ground, in the vicinity of Guápiles, a small village at the terminus of the Old Line Railroad, fifty-nine miles northwest of Port Limon. Here we found reasonably comfortable quarters in a small hotel conducted in connection with the general store.

The representatives of the United Fruit Company were uniformly courteous, and without their co-operation, the work would have been very difficult indeed. My thanks are due especially to Mr. W. E. Mullins, General Manager, Mr. Wilson of Guápiles, and Mr. Doswell of Port Limon. I am grateful also to Senor Juan Quesada, Senor Rafael Tristán and Mr. W. F. Milkevitch, of Kiew, Russia, all of whom contributed much to the success of the expedition.

Part II.—Ecological Conditions.

Guápiles lies on the northern slope of the Volcan Turrialba, at an elevation of about eight hundred feet. Rainfall is of almost daily occurrence throughout the year, the seasons not

being strongly demarcated, as they are in the highlands. There are occasional periods of greater precipitation, and at these seasons there may be several days of continuous rainfall, without intermission.

The country about Guápiles is fairly level, with a gentle northward slope. Once the greatest of Costa Rican banana districts, its usefulness in that direction was destroyed by the inroads of a blight which destroyed the growing fruit. When it appeared useless to combat this trouble longer, the plantations were levelled and the land given over to cattle producing. The pastures are of considerable extent, running back on both sides of the railroad from one to two miles, where the forest commences.

The pastures or *potreros,* are very rough in character, constant effort being necessary to keep the bush from reclaiming its own. Each stream is marked by a line of trees and bushes, often extending into bits of very tangled jungle, and scattered trees are numerous. Each pasture is divided from the next by fences of barbed wire. As dead posts are unable to withstand for long the continual rain, small stakes of a softwood tree are used. These stakes begin to sprout almost at once and soon reach a height of fifteen to twenty feet. They thus form permanent fence-posts and their thick foliage provides the birds with excellent hiding and nesting places.

Bird life at this altitude is exceedingly varied, but individuals, at least at the time of our visit, were not nearly so abundant as we had been led to expect. At this season, of course, their numbers were at their lowest ebb, as nesting was just commencing, and few young birds were as yet on the wing. The adults were paired and scattered, and as there was very little fruit ripe at the time, there was no concentration.

A sharp line was noticeable between the birds of the open and of the jungle, neither group usually entering the domain of the other. The most typical species of the *potreros* were Parrots and Parrakeets (*Conurus finschi, C. aztec* and *Pionus senilis*) ; the Tanagers (*Rhamphocoelus passerinii, Thraupis cana cana, T. palmarum melanoptera, Tangara larvata larvata* and *Euphonia luteicapilla*) ; Flycatchers (*Myiozetetes texensis*

texensis, M. granadensis, Legatus albicollus, Tyrannus albicollis satrapa, Pitangus sulphuratus derbianus and *Megarhynchus pitangua*) ; Bonaparte Tawny Robin (*Planesticus grayi casius*) ; six of the *Fringillidæ* (*Saltator magnoides medianus; Arremonops conirostris richmondi; Sporophila morelleti; S. corvina; Tiaris olivacea pusilla* and *Volatinia jacarini splendens*) ; the Sooty Synallaxis (S. *pudica nigrifumosa*) ; and of course the two Vultures (*Catharista urubu brasiliensis* and *Cathartes aura aura*). The great Cacique (*Gymnostinops montezuma*) is of frequent occurrence, its colonies usually being found in open places rather than in the forest.

On entering the jungle, the bird life changes at once. Antthrushes (*Formicariidæ*) and Woodhewers (*Dendrocolaptidæ*) creep among the bushes or flit from trunk to trunk. Trogons (*Chrysotrogon caligatus, Trogonurus puella* and *Curucujus massena*), Black-chinned Jacamars (*Galbula melanogenia*) ; Puff-birds (*Bucconidæ*) and Cotingas (*Cotingidæ*) are often seen. Motmots (*Momotidæ*) are represented here by three species, but careful search did not disclose a single specimen.

There, are of course, many mammals. A small deer (*Odocoileus costaricensis*) is abundant, as are Pecarries (*Tayassu tajacu*), Agoutis (*Dasiprocta*) and Spotted Cavies (*Coelogenys paca*). A jaguar was killed during our stay at Guápiles. There are Raccoons (*Procyon lotor fernandezi*), Opossums (*Didelphys* and *Marmosa*) and Coatis (*Nasua rufa*), two species of squirrels (*Sciurus*) and at least two monkeys, the Geoffroy Spider (*Ateles geoffroyi*) and a small Capuchin (*Celius hypoleucus*).

Snakes were not abundant and few species were noted, among them *Spilotes corais,* a coral (*Elaps*), a coral-like species (*Leptognathus*), a Tree-snake (*Himantodes*), Fer-de-Lance (*Lachesis lanceolatus*) and a striped snake (*Dromicus*). Lizards of several species were abundant, especially a small *Anolis,* which lived in the shrubbery everywhere, leaping with frog-like agility.

The great Marine Toads (*Bufo agua*) were not nearly so numerous as observed by the writer in British Guiana, and were never abundant. A beautiful little red frog with blue

legs (*Dendrobates typographus typographus*) and a tiny tree-toad (*Hylotes underwoodi*) were found in the forest. Good-sized tree-toads (*Smilisca baudini*) were fairly common about Guâpiles, trilling nightly from the surrounding *potreros.* A large green frog (*Rana chyrosprasina*) inhabited the banks of the streams, but was very shy and difficult to collect.

The country is well drained, the streams being numerous and very swift. One small brook, not more than three feet wide, near our headquarters, contained numerous fishes—small eels and catfishes, at least three species of Cichlids, *Astyanax æneus costaricensis,* and six species of the *Pœciliidæ* (*Rivulus isthmensis, mollienisia sphenops tropica, Alfare cultratum, Priapichthys annectens, Pœciliopsis pittieri* and *Brachyrhaphis umbratilis*).

Insects were not numerous. Mosquitoes were troublesome only during the early morning, but *bete rouge,* ticks and a small black fly were plentiful enough.

As the object of the expedition was the collection of living specimens, few skins were made, so these notes must be confined to those birds which we were able to observe or capture without the use of guns. No attempt has been made to give a list of species seen, as this ground already has been admirably covered by several writers, chiefly Robert Ridgway [1] and M. A. Carriker, Jr., [2] and mention is made only of those birds concerning which some observation was made.

Part III.—Notes on the Birds.

April 4, 1914-May 10, 1914.

Cresciscus cinereiceps (Lawr.). Ashy-Headed Rail.

This tiny rail was abundant about Guápiles, being found in pairs wherever the ground had the slightest tendency toward marshiness. Its call-note is a sharp cackling, strikingly like that of *Synallaxis pudica nigrifumosa....* The birds were breeding and on April 9, 1914, a nest was found. It was globular, about six inches in diameter and built of narrow-leaved grasses, the entrance hole being at the side. It was placed in a small clump of grass, about six inches from the ground, in the center of a

[1] Ridgway, Robert, Birds of Middle & North America.
[2] Carriker, Jr., M. A. An Annotated List of the Birds of Costa Rica, including Cocos Island.

diminutive marsh. The nest contained three eggs, creamy white, lightly blotched with pale brownish. On the following day the female was flushed from the nest, which was found to contain a single downy chick, the others perhaps having joined the father.

The young bird was clothed in thick black down, the feet and tarsi being of the same color. The beak was pure white, with a small black mark at each side of the lower mandible. The iris was dark brown.

A few days later, an adult bird was seen in a small patch of brush. When pursued it attempted to hide under some leaves and was caught by hand without difficulty.

Asarcia variabilis (Linn.). MEXICAN JACANA.

Not abundant about Guápiles, conditions there not being suitable. A single specimen, in the white-breasted immature plumage, was seen in a marshy pasture. It was not shy, and flew up silently when disturbed.

Ajaia ajaja (Linn.). ROSEATE SPOONBILL.

Although abundant along the Pacific side of Costa Rica, this bird seems to be uncommon on the Carribean coast. A single bird, not quite adult, was taken in a swamp about four miles north of Guápiles.

Sarcoramphus papa (Linn.). KING VULTURE.

We had been led to believe that King Vultures were both shy and rare in Costa Rica, but subsequent observations proved this not to be the case. Soon after our arrival we noticed a pair sailing overhead in company with a cloud of Black Vultures (*Catharista urubu brasiliensis*). A few days later, we came across a dying calf, surrounded by a great number of the later birds, not more than one hundred yards from our headquarters. A bullet soon ended its misery. Next morning, the carcass was untouched, although Black Vultures were in constant attendance, and on the following day a King Vulture in dark plumage was sitting on it. The bird took a leisurely flight when ap-

proached and examination showed the carcass undisturbed. The next day, three days after the death of the calf, four Kings, two adult males, one immature male and a female were feeding. These birds stayed about all day and were not at all shy, permitting persons to approach within one hundred feet. They devoured a great part of the carcass, and finally took themselves off, leaving the remainder to the greedy Blacks, which had been standing about at a respectful distance.

Catharista urubu brasiliensis (Bonap.) SOUTH AMERICAN BLACK VULTURE.

This is the common vulture of Costa Rica. It is abundant everywhere, perching on the houses, selecting the tid-bits from the wagons of city refuse collectors, quarreling with dogs and poultry over morsels in the streets and industriously following its mission as general scavenger.

It is customary to stretch the hides of freshly killed cattle in accessible places and on several occasions vultures were noted in the act of stripping them of bits of fat and flesh, apparently doing so without injury to the hide.

It is of interest to note that the calf referred to under *Sarcoramphus papa* was dead three days before a really serious attack was made upon it. When it was first discovered, although not quite dead, the birds had removed its tail and made small incisions at various parts of its body. As soon as it was dead the eyes were extracted, but after that it remained untouched until the third day, when it was quickly devoured. This would seem to indicate that the birds were unable to penetrate the animal's hide until decomposition had softened it considerably. They hold the King Vultures in great awe, the coming of one of these great birds being the signal for the withdrawal of its meaner relatives.

On another occasion a King and a great number of Blacks were noticed perched on and about an isolated shed in a back *potrero*.... Investigation showed the shed to contain a quantity of fat, cut in strips and hung up to dry. The walls of the shed were formed by slats, the apertures being so narrow as to make the inside too dark to permit the contents to be seen

from the outside. It had not been in use for some weeks, so the birds were not in the habit of finding food there, and it seems most probable that they had been guided to the spot by the slight sense of smell which these birds seem able to exercise at short distances.

Cathartes aura aura (Linn.). NORTH AMERICAN TURKEY VULTURE.

It is curious to note that while the Black Vultures are of the South American form, the Turkey Vultures belong to the same subspecies as those of North America. They are not abundant in Costa Rica, more than a pair seldom being seen at one time. They rarely stay about slaughter houses and similar places after the habit of the Blacks, but are usually seen alone, prowling about the *potreros*. They were shy and seemed to be in fear of the Blacks, perhaps because of the superior numbers of the latter.

Nyctidromus albicollis albicollis (Gmel.). CUIEJO.

This is the only common Goat Sucker about Guápiles. In the daytime, specimens were frequently disturbed as they sat on or near the ground, and at night their calls resounded from all sides.

On April 19th, three nests of this species were discovered in some open brush along an abandoned tramway. Two were about twenty-five feet apart and the other about one hundred feet distant. Each contained two pale brownish eggs, blotched with chocolate; all were fresh. One set was deposited in the hollow of a great, dried leaf; another between several smaller leaves and the third on the ground beside a large stone. No other nests were found during the entire trip and as there appeared to be nothing to distinguish this particular locality from the surrounding country, their occurrence there seems a curious coincidence.

Chrysotrogon caligatus (Gould). GARTERED TROGON.

This is the most abundant Trogon about Guápiles. It is met with in the bits of bush along streams and in the pastures

and may also be seen in the forest itself. It seems also to have a fondness for banana plantations, where several were seen. They are easily located by their call, a high pitched monotone resembling "toot, toot, toot—toot," rapidly repeated. This call was given alike by male, female and young, no difference being distinguishable.

This bird is almost entirely fearless and is easily approached. It is usually seen low in the trees. It was often noticed hawking for insects, which it caught with great dexterity. It feeds also on berries, which it plucks while on the wing.

On April 12th, a young bird, apparently about two weeks old, was found perched in a tangle of bushes near a banana plantation. On the following day another, and on the next a third, were taken near the same place. They were similar in size and appeared to be from the same nest. Only one pair of adults had been seen in the vicinity, which lends strength to this supposition. Unfortunately the nesting site could not be located. Although the youngsters were able to fly, the parents were evidently still caring for them, for when one was brought to the vicinity in a cage, the mother came at once to feed it.

Curucujus massena (Gould). MASSENA TROGON.

This bird was less abundant than *caligatus* and less easily approached. The brilliant red abdomen is a conspicuous identification mark, although even then it is not always easily seen among thick foliage. It keeps higher in the trees than *caligatus*.

The note of this species is a series of slow, guttural clucks very strikingly galline in sound, and resembling that of *caligatus* only in the method of delivery. Males only were heard calling.

Trogonurus puella (Gould). JALAPA TROGON.

Two specimens only of this species, male and female, were observed. These birds were seen in the jungle near the Rio Toro Amarillo, about four miles south of the railroad, at an altitude considerably below the usual range of this species.

When first noticed, the birds were feeding on the fruit of a palm, about fifteen feet high. When disturbed they perched

not far from the ground providing an excellent opportunity for observation. They were male and female and busily engaged in what appeared to be courtship manoeuvres. The voice of this species is intermediate between those of *Curucujus massena* and *Chrysotrogon caligatus,* in every point—tone, volume and time. The notes of the male are slightly higher and clearer than those of the female. The former would start off with his *"ku-ku-ku———ku,"* raising his tail high over his back, but not spreading it. Sometimes he ducked his head and slightly opened his wings. The female would at once respond, raising her head and calling her more guttural "kuk-kuk-kuk" but not raising the wings or ducking. There was an evident attempt at alternation, but sometimes one would not wait for the other to finish and often they became so mixed that both were calling at once. This seemed an almost endless performance. Sometimes the birds sat side by side, their feathers touching, at others as much as ten feet separated them. At intervals the male would make short flights to a distance of fifty or one hundred feet. At these times he was silent. Soon he would return, flying very swiftly, with a loud buzzing of wings, to renew his love song.

Crotophaga sulcirostris Swains. Groove-Billed Ani.

Although the country about Guápiles is largely given to stock breeding, Anis were not nearly so numerous as this species and *C. ani* have been observed in other countries. A few are usually in attendance on the cattle but they are far from abundant, as compared with former experiences.

There has been much controversy concerning the nesting habits of these birds. So much evidence has been advanced to demonstrate a communal system, under which several females lay in a single nest, that there is no denying the fact. This habit is not, however, invariable. Near our headquarters was a small orange tree, a favorite nesting place throughout the tropics, the sharp spines affording perfect protection. Here a pair of Anis had built their nest of sticks and were incubating. The female was first seen on the nest on April 2nd. Other Anis were in the vicinity, but we watched carefully day after day, and no other was ever seen in the tree. If ever a strange bird

approached, the male of the nesting pair attacked it fiercely, driving it off. When the young birds, three in number, finally left the nest, they were guarded carefully by the two parents, who watched them assiduously and did not permit the approach of any other bird. Later another pair, accompanied by two youngsters, was seen catching insects in some long grass. Whether or not this is the usual nesting habit of *Crotophaga sulcirostris* in Costa Rica I cannot say, but these birds, at least, were paired in orthodox bird fashion.

Campephilus guatemalensis guatemalensis (Hartl.).

GUATEMALAN IVORY-BILLED WOODPECKER.

A young bird of this species, apparently about three weeks old, was collected on May 5th. It was able to fly but was quite fearless and was caught with no difficulty. The nest was not seen.

Synallaxis pudica nigrifumosa (Lawr.). SOOTY SYNALLAXIS.

This little Oven-bird is one of the most characteristic species about Guápiles. Wherever there is thick, tangled undergrowth along streams or in the *potreros,* its harsh, rail-like notes are certain to be heard. Many characteristic nests were found. They are usually from two to six feet from the ground in a clump of bushes. The entire structure is of course sticks, the nest being about a foot in length and somewhat less in diameter. It is domed at the top, with a long entrance tunnel, the lumen being only sufficiently large for the passage of the bird. On April 5th a nest containing two bluish eggs was found, and on April 19th, we saw an adult pair accompanied by two full-fledged young.

Carpodectes nitidus Salvin. SNOWY COTINGA.

This beautiful bird is so rare that even a sight of it is an exciting experience. The species was observed on three separate occasions, but always high in the trees. We first saw two white males and a single female flying about the tops of some forest giants in a bit of pasture jungle about a mile south of

Guápiles. We next saw two males and two females under similar circumstances up the slope of Turrialba. One morning while sitting at breakfast, a snowy bird was observed crossing behind the house. We at once went outside and were rewarded by seeing five more adult males fly across singly and join the first in the top of an isolated tree in the garden. There were no females and the flock soon made off silently. We did not see them again nor could we find a nearby fruit tree in which they might have been feeding.

Manacus candei (Parzudaki). CANDE MANAKIN.

On April 15th, while following a tramway up the slope about two miles north of Guápiles, a loud snapping noise was heard emanating from the bush. It was a curiously familiar sound and seemed worthy of investigation. On penetrating the tangled underbrush for a hundred feet or so, a tiny glade was disclosed, about which a number of brilliant black, white and yellow birds were flitting. As soon as one perched for a second, it was recognized as *Manacus candei*. There were about twenty in the flock, the sexes approximately even. All were moving actively through the bushes, feeding on insects. Often a sombre green female would emit the single shrill call-note, which would be answered by several males. The males, besides the call note, snapped their beaks frequently, making a sharp sound, audible at a considerable distance. They also made a crackling noise, which seemed to be a very rapid series of beak-snappings. This was sometimes followed by a curious, deep grunting note.

The males pursued each other incessantly, moving in short, swift flights accompanied by a loud buzzing sound made by the emarginated outer primaries.

Very often during a period of several weeks the birds were observed in the same locality. They were never seen more than two hundred or three hundred yards from their favorite glade, and were never seen on the west side of the tramway. There was no water there, and nothing seemed to distinguish the spot from the surrounding jungle.

One male examined was in breeding condition. The stomach contained the remains of some small fruit, as well as the hard parts of insects.

Tyrannus tyrannus (Linn.). KINGBIRD.

While there are few records of the occurrence of this species in Costa Rica, Carriker[1] says it is not uncommon there as a winter visitor.

On April 19th, we saw a flock of several hundreds of these birds near Guápiles. Some small, winged insects of which we could not secure a specimen, were swarming, and the Kingbirds were dividing their attention between these and the small, purplish berries of a nearby tree. For more than a week, the flock stayed in the vicinity, feeding much on small fruits. They were silent, even on the frequent occasion of clashes with other flycatchers, especially *Pitangus* and *Myiozetetes,* in which they seemed well able to hold their own.

Planesticus grayi casius (Bonap.). BONAPARTE TAWNY ROBIN.

This bird certainly is the finest songster of the Caribbean lowlands. It is abundant about Guápiles where its beautiful song is a characteristic feature. It sings usually early in the morning and late in the afternoon. During the breeding season, there are few moments at these periods of the day when at least one bird cannot be heard.

We found many nests of this species, the first one on April 7th. The favorite site is in the fork of the trees composing the "live fences." As the shoots grow up about the original post, they form a perfect basket, with the top of the post for a bottom. This soon becomes covered with mosses, lichens, and various ferns and parasites, so that it is possible to hide a nest perfectly. The nests are made of mud, moss and lichens, and lined with rootlets. The five or six nests we found each contained two eggs or young birds. The eggs are pale bluish, heavily spotted with chestnut.

Psilorhinus mexicanus cyanogenys (Sharpe). CENTRAL AMERICAN BROWN JAY.

This species was abundant in the more open parts of the forest and about the *potreros.* It was seen almost invariably in company with *Gymnostinops montezumae,* the two species

[1] An Annotated List of the Birds of Costa Rica, including Cocos Island, p. 687.

uniting in good-sized flocks which searched the woodland for anything edible. The Jays seemed to act as sentinals for the rather stupid Caciques, giving their shrill alarm notes at the slightest sign of danger. It is of interest to note that a similar association of a Jay and a Cacique, both of different species from the ones here mentioned, has been recorded from British Guiana, by Mr. C. Wm. Beebe.[1]

As the Jays were calling, an audible popping noise could be distinguished, following the note. Careful observation showed a distension on the fore-neck, which was alternately inflated and collapsed, the cracking sound occurring at the point of greatest inflation. Examination of a freshly killed bird disclosed a sac of skin at a point just anterior to the point of the sternum. It was quite flat and measured 14 mm in length.

A captive specimen of *Psilorhinus morio morio* (Wagl.) in the Zoological Park exhibited a similar character. This bird never uttered a vocal note, but distended the cervical sac whenever he was excited, making a popping sound which could be heard at a distance of several yards. On examination of this bird after death, the sac was found lying between the branches of the furculum, 1 mm. anterior to their point of union. Deflated, it measured 13 mm. from base to tip and 19.5 mm. along the base, the tip being rounded. Dissection showed this protusion to have been formed by a simple evagination of the dermal covering of the neck. A narrow band of muscle fibres lying in the skin surrounded the base of the sac, but as these bands occur in closely allied forms (as *Cyanocitta cristata*) it is doubtful if they perform a special function in this case. The sac communicated directly with the praebronchial or interclavicular air-sac (*Saccus interclavicularis*), through a large opening in the furcular membrane, and doubtless received its air from this source.

Seirus noveboracensis noveboracensis (Gmel.). NORTHERN WATER-THRUSH.

One living specimen was taken on April 9th and a second on the 15th. Two others were noticed during the same period.

[1] Our Search for a Wilderness, p. 174.

Cassidix oryzivora mexicana (?) (Less.). MEXICAN RICE GRACKLE.

Cassidix oryzivora is a rare species in Costa Rica, there being but two authentic records of its occurrence, and one of these is rather obscure.[1] There is some doubt as to the form to which Costa Rican specimens should be referred, so *mexicana* is used advisedly.

On April 26th, while examining nests of *Zarhynchus wagleri wagleri,* one was found containing two young birds about two weeks old. One differed markedly from the other, and proved to be a *Cassidix.*

Dr. Emil A. Goeldi[2] has described the parasitic habits of *C. oryzivora oryzivora* of Brazil, which deposits its eggs in the nests of *Cacicus persicus,* which is the common Cacique there. *Zarhynchus* is the only Cacique nesting in colonies in the higher parts of Costa Rica, and it is not remarkable that *Cassidix* should adopt this species for rearing its young.

The feathers of the young bird were quite black, the legs and feet also black, iris dark hazel. The beak and bare portions of the face, including the lores, space in front of the eyes and base of the beak, which were bare of feathers, entirely white. The gape was pale yellow. The bird exhibited the greedy habits usual in parasites and soon was able to care for itself and was brought safely to the Zoological Park.

On May 25th, faint signs of dark coloring were observed in the beak. These gradually increased, so that the change to the pure black of the adult was seen to be under way. The chief points of color increase were at each side of base and tip of both mandibles, although the patches were very irregular.

On June 25, it was noted that the anterior portions of the face and the lores were covered with pin-feathers, which soon clothed these parts. The bill was now much darker, the white tracts being greatly restricted. By August 10, the change was practically complete, only faint traces of white at the tip of the upper mandible remaining.

It is not possible to determine the particular subspecies to which this bird is referable until it becomes adult.

[1] Carriker. List of the Birds of Costa Rica, p. 832.
[2] Ibis, Vol. III. Ninth Series, 1897, pp. 361-365.

FIG. 113. June 25, 1914.

FIG. 114. July 25, 1914.

INCREASE OF PIGMENT IN THE BEAK OF *CASSIDIX ORYZIVORA MEXICANA* (Less).

On May 5th, while inspecting the nests of a colony of *Gymnostinops montezuma,* a recently hatched bird was found in company with a young *Gymnostinops.* This nestling's skin was white, with occipital, humeral, dorsal and lateral tracts, as well as a slight scattering on the thighs, well covered with long, dark gray down. The beak was white and the gape wide and yellowish. It was in striking contrast with its blackish, downless nest-mate and was no doubt a young *Cassidix.* Its behavior was quite in contrast to that of *Gymnostinops,* which shrunk to the bottom of the nest when disturbed, while the young interloper gaped eagerly for food. The two birds were of approximately the same size and equally well nourished. They could not have been more than two or three days old.

In a second nest was found an egg of *Gymnostinops* accompanied by another (Fig. 116) of quite different appearance. This egg is spotless white, rough in texture and slightly glossed. It measures 36.1 mm x 26.0 mm, which approximates the dimensions of two eggs of *Cassidix oryzivora oryzivora* in the collection of the British Museum,[1] and substantiates the belief that the present specimen is referable to *C. oryzivora mexicana.* It is of interest to note that the egg of *Gymnostinops montezuma* was addled and evidently deserted, while its fellow was quite fresh.

It is remarkable that with three separate evidences of the presence of *Cassidix,* not one adult bird was observed, although much time was spent in observation of colonies of both *Gymnostinops* and *Zarhynchus.* Carriker[2] records that in several years of collecting in Costa Rica, he saw but a single specimen of *Cassidix,* and this one at Guápiles. This bird was referred to *C. oryzivora mexicana.*

Gymnostinops montezuma (Less.). Montezuma Giant Cacique.

This Oropendula apparently is the most abundant Icterine bird of the Caribbean lowlands. Its colonies are of frequent occurrence and the birds, often in company with *Psilorhinus mexicanus cyanogenys,* are almost ubiquitous. They were

[1] Catalogue of the Collection of Eggs in the British Museum, Vol. V, p. 372.

[2] Birds of Costa Rica, etc., p. 832.

breeding at many points about Guápiles, affording an excellent opportunity for observation.

The tree most commonly used by the Caciques is known locally as the *Ceiba.* The trunk is smooth, with very thin bark, which affords no hold for tree-climbing animals, and rises to a great height before any branches spring out. The base is reinforced by wide-spreading buttresses. The trees selected are usually isolated and the majority are in open *potreros* or in similar locations, although occasionally they are in open forest. It was noted, however, that the branches are never in contact with those of neighboring trees.

The nests (Fig. 115) vary in number, from half a dozen to as many as 100. Not more than one-third of the nests in any colony examined were in use, and the occupied nests could be distinguished by their fresher appearance. It seems to be evident that nests once used are seldom if ever repaired, the birds usually building new nests, clustered in another part of the tree.

In only two cases among the many colonies observed, was there evidence of association with wasps, the birds seeming to depend for protection on the great height of the trees.

The nests are in the form of pendulous sacks, the opening being at the top, which is not domed as in *Cacious persicus.* The length of the many examples measured varied from thirty to forty-eight inches, the average being about thirty-six inches. The diameter of the more globular lower portions averaged nine inches. In all cases, they were built chiefly of the aerial rootlets of various tree parasites, mixed with coarser, weed-like material and here and there a spray of Spanish Moss. The weaving is rather coarse, and the nest in general is not nearly so fine as that of *Zarhynchus wagleri.* The nests contain a mass of broken dried leaves, to a depth of two or three inches, which form a cushion at the bottom.

In all, the nests of three separate colonies of *Gymnostinops* were examined. The first, on April 29, consisted of nine nests of which but three were in use. Each contained a single youngster about one-half grown. In the second, on May 5, there were forty-nine nests, of which fifteen were occupied. Fourteen contained young in all stages from newly hatched chicks to nearly

FIG. 115. NEST OF *GYMNOSTINOPS MONTEZUMA*.

FIG. 116. EGG OF *CASSIDIX ORYZIVORA MEXICANA*.

FIG. 117. EGG OF *GYMNOSTINOPS MONTEZUMA*.

fledged birds, while one contained the two eggs mentioned under *Cassidix.* In only one case did a nest contain two young *Gymnostinops,* while a *Cassidix* shared another with the single rightful inmate. The third colony, also examined on May 5, was one of nineteen nests. Only three were occupied, each containing a nearly fledged young bird. It seems probable that other young had flown, as some of the nests showed signs of recent occupancy.

It will thus be seen that of twenty-one nests containing young or eggs, in only one instance was there more than one occupant. It seems evident, then, that the normal complement of this species is but a single egg.

The egg collected measures 42.4 x 25.1 mm., seeming to be rather abnormal as to length (Fig. 117). It is a very pale bluish white, lightly spotted throughout, but heavily encircled at the larger end with chocolate blotches.

The newly hatched chicks are blackish, the skin leathery and shiny, and quite devoid of down. The beak is black, with both mandibles tipped with yellow, the gape being pale yellow.

The stomach of one young bird examined was crammed with insect remains and fruit seeds. Several very large locusts were represented, the bird apparently not being inconvenienced by the huge tibial spines.

The food of the adults is evidently of a highly varied character. Many kinds of fruits and berries enter into it, as well as such animal food as they chance to come across. Birds were observed carrying locusts, roaches and other insects to the young, and on one occasion a freshly-killed mouse was found in a nest. A dead frog given to a captive specimen was seized and passed to and fro in the great beak. The frog was then held down with one foot, Jay fashion, and each leg carefully broken, when it was swallowed without further ado.

The notes and display of the male *Gymnostinops* have been described too often to be repeated here. It was noted, however, that the male often flew against a nest with great force, so that it swung about wildly, and that the curious gymnastic performances were executed while the bird hung sideways in this perilous position.

Zarhynchus wagleri wagleri (Gray). WAGLER GIANT CACIQUE.

This species is found only in the highlands and usually is not found below 2,000 feet. A tramway runs from Guápiles up the slope of Turrialba for about six miles. About four miles up, at an estimated altitude of 1,800 feet, was a large colony of *Zarhynchus,* and farther on a smaller one.

The trees in these cases were not of the species chosen by *Gymnostinops.* They were less tall, narrower in girth and with the small branches covered with spines. Neither colony was associated with wasps.

The visit was made on April 26. The smaller group numbered twenty-one nests, the other forty-three, a total of sixty-four. Of these, but thirty-nine were occupied. Twenty-two contained eggs and seventeen held young in all stages of development. Of the latter one held two nearly fledged young, beside the nest which was shared with a *Cassidix,* and two others two small birds each, while two contained pairs of eggs. Thus, out of a total of thirty-nine occupied nests, only five contained more than one egg or chick. It seems, therefore, that the normal clutch of this species, as well as *Gymnostinops,* is but one egg.

The measurements of six eggs collected are as follows:

32mm. x 22.65mm.	32.9mm. x 22mm.
32.55mm. x 22.2mm.	33.3mm. x 22.6mm.
34.5mm. x 23mm.	34.2mm x 22.7mm.

They are pale greenish blue, blotched with dark brown, more heavily at the larger end.

The young have the beak quite white and the gape pale yellow.

The nests of *Zarhynchus* were composed of the same materials as were those of the larger species but, as would be expected, the former are considerably smaller. Many were measured, and all were between twenty-four and thirty inches in length, the average being about twenty-eight inches, while the diameter at the bottom averaged seven inches. The weave is much closer and finer, and the nests of the two species are dis-

tinguishable at a glance by this character alone. They were lined with bits of long, narrow leaves, some still green, of a different species from those used by *Gymnostinops*. They may have possessed some quality unpleasant to bird lice, for while the nests of *Gymnostinops* were infested with them, there were none in those of the present species.

Rhamphocoelus passerinii Bonap. PASSERINI SILVER-BEAK TANAGER.

The most casual traveler in Costa Rica cannot but be impressed by the remarkable conspicuousness of this common bird. It is abundant everywhere, and the flashing scarlet of its lower back can be seen at a considerable distance. Very often the wings are drawn down so that the red patch is exposed to its fullest extent, and a more patent signal to passing birds of prey could hardly be imagined. Its very evident success in life can be explained only by its habit of living in the vicinity of thick bushes, into the depths of which it darts when danger threatens.

Arremonops conirostris richmondi Ridg. RICHMOND SPARROW.

This is one of the most abundant birds about Guápiles. It has a great variety of queer notes, its *chug-chug-chug* being characteristic of the *potreros*.

Nests were found frequently. They were placed close to the ground in a clump of weeds or grasses, in open places. They were built of coarse dried grasses and roots, domed, and with the entrance at the side. One found on April 6 contained two newly-hatched chicks, an unusually early date. The eggs are plain white, usually four in number.

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME I, NUMBER 19.

NATURAL HISTORY OF THE WHALE SHARK

RHINEODON TYPUS SMITH

BY
E. W. GUDGER PH.D.
PROFESSOR OF BIOLOGY
NORTH CAROLINA STATE NORMAL COLLEGE

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

MARCH, 1915

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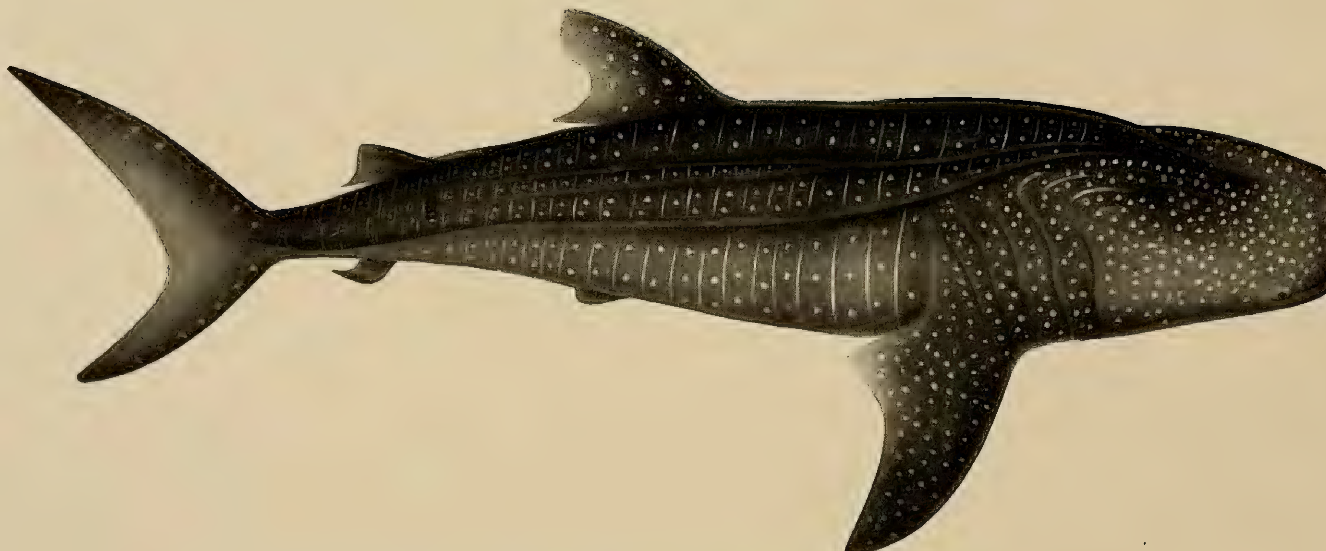

FIG. 118. *Rhinodon typicus.* PLATE 26 OF SMITH'S ILLUSTRATIONS OF SOUTH AFRICAN ZOOLOGY.

From Bean (1905).

NATURAL HISTORY OF
THE WHALE SHARK
RHINEODON TYPUS SMITH

By E. W. Gudger, Ph. D.
Professor of Biology,
STATE NORMAL COLLEGE, GREENSBORO, N. C.

Narrative.

In June, 1912, while a guest of the Marine Biological Laboratory of the Carnegie Institution of Washington at Tortugas, Florida, one of the laboratory men whose home is at Miami brought me a copy of the *Miami Metropolis,* giving an account of the capture of some great fish near that city. Later papers gave other and fuller accounts, but as the descriptions of the animal were very defective, it was impossible to decide what it was. On the whole, however, since all descriptions said that it was enormous in size and marked with white spots, I finally concluded that it was probably an Orca, or Killer Whale.

Toward the close of the following month (July), in passing through Miami on my way north, I stopped off for a couple of days and had an opportunity to see the skin of this huge animal, and to talk with its captor, Captain Charles Thompson. At this time, I had no knowledge of the Whale Shark, save an indefinite recollection of a picture of one and certain statements as to its great size and its occurrence on the east coast of Africa found in *Holder's Zoology,* which I had studied as a boy. However, the shagreen-like skin and the strap-shaped gill-slits, plainly showed that it was a shark.

This skin, which was the most enormous thing of the kind that I had ever seen, was hung over a long, wooden support, in a house built to receive it on the bank of the Miami River. Despite the fact that the skin had been cut and torn by harpoons and bullets, and had suffered much at the hands of the gang of men which Captain Thompson had help him skin the fish, it

was in fair condition and in the hands of a good taxidermist was capable of making a fine mount. Captain Thompson informed me that he was in communication with such a man, and that in the meantime he was preserving the skin from decomposition by drenching it several times a day with strong brine and by sprinkling it with formalin.

The general color of the skin was brownish with large pale, white spots, perhaps as large as a silver dollar. No longitudinal bars, such as will be described later, and no short transverse markings, were noticed. The spread of the tail fin was so great that a tall man could stand under the tip of the upper lobe. The mouth and jaws, which had been cut out with the skin, were very large, so large that a man could have gotten within them. The teeth, which were in a band about two inches wide in each jaw, were very minute, prickle-like, recalling forcibly the old-fashioned "wool cards." Captain Thompson emphasized the fact that "the fish had no bones," save the backbone, a number of segments of which he showed me. These were cartilaginous, about five inches in diameter, bi-concave in form, and were of a yellowish-brown color, apparently due to the oil contained in them.

During the fall and winter of 1912-1913, I was in somewhat infrequent communication with Captain Thompson, who very kindly agreed to give me the data about the capture of the fish, but he was so engrossed in getting the skin mounted for exhibition for the winter tourists that he did not find time to do so. The mounting of this skin was a Herculean task, and was only done after some months' incessant labor.[1] This work was done by and under the direction of Mr. J. S. Warmbath, a professional taxidermist, of Washington City. The post-card figures of it, kindly sent me by Captain Thompson, with permission to publish, show that the work was well done.

On April 26, 1913, at the meeting of The North Carolina Academy of Science, I exhibited the photographs sent me by Captain Thompson and read a short paper on this fish as a preliminary report. This was published in *Science* for August 22. On May 3, Doctor Hugh M. Smith read a letter describing the

[1]It may be noted here that in preparing the skin nearly half a ton of shavings was removed from it.

capture and exhibited pictures of this shark at a meeting of the Biological Society of Washington. An abstract of his remarks appeared in a report of the meeting in *Science* for August 29.

In the *Bulletin* of the New York Zoological Society, for November, 1913, Doctor C. H. Townsend wrote very interestingly of this Whale Shark, and gave two figures, one of the mounted specimen and one of the fish taken shortly after its capture. The latter, showing a man crouching in the mouth cavity, gives an idea of its enormous size. It is reproduced herein as Figure 119.

Early in May, 1913, I was definitely informed of what had reached me through rumor previously, namely, that Captain Thompson had left Miami to exhibit his shark in the towns along the East Coast of Florida. On my reaching Tortugas toward the close of the month, our Miami men reported that he was understood to have the *Rhineodon* on exhibition in Atlantic City, and this was confirmed when I stopped in Miami, on July 29.

This was a great disappointment to me, for I had hoped to see and make careful descriptions and measurements of the mounted fish, and to get from Captain Thompson a full account of the capture of this rare animal.

However, I ascertained that, at the time of the capture of this shark, Captain Thompson's boat was chartered by Mr. Charles T. Brooks, of Cleveland, Ohio. After some difficulty, I succeeded in getting in communication with Mr. Brooks, and am indebteded to him for the following excellent and invaluable account of the capture. Mr. Brooks has put the matter so well that I cannot do better than quote him verbatim:

"I had engaged Captain Charles Thompson, of Miami, and his boat 'Samoa,' with Bob Denny as assistant, to go south along the coast from Miami for tarpon in the latter part of May, 1912. This was after the season had closed at Miami. There were just the three of us on this expedition. We finally anchored just below Knight's Key, about one-half mile inside from the old Florida East Coast dock. One morning the Captain saw the tail of a large shark, as he supposed, within a few feet of the viaduct. He asked me if I would like to see a shark harpooned, and I said that I would. He then began to be impressed with

the idea that this was the largest shark he had ever seen. We immediately took the launch and row-boat attached to it, and started to the fish which was then moving slowly along with its tail above water, parallel to the viaduct and only a few feet from it. The Captain shouted to a man on top of the viaduct, asking him if he had seen the shark. He replied that he had seen it, but that it was not a shark—and that he did not know what it was, and that it had been around there for three or four days. We approached closer, and finally the boat was right over the fish, and we could see his spotted back three or four feet below the surface. We were in this position when Captain Thompson threw the harpoon. The fish was harpooned at about half past nine in the morning. We called to our aid some fishermen who happened to be near with their boats, and with their help, succeeded after a while, by means of a sharp hook thrown over the fish's nose, in getting his body nearer the surface of the water, and from time to time, during the day, shot him in the back, perhaps forty or fifty times with a rifle. We tried shooting him with a shotgun with number 2 shot at a distance of perhaps two feet from his back, but the shot bounded off, leaving their impression in a circle of about an inch and one-half or two inches, for the depth of perhaps an eighth of an inch in his back.

"The fish circled several times in from the viaduct, perhaps half a mile, coming back again to the viaduct, and at one time when the tide was running rapidly out about one o'clock in the afternoon, we thought that he might go outside. The boats were carried by the tide outside the viaduct, but the fish remained inside and finally started further inside and made another circle.

"I was surprised that the fish did not put up any fight. He proved to be a sluggish monster, and seemed to fail to realize that anything particular was happening to him. He kept circling in his slow way, moving his tail, which was always above water, in an arc of about eight to ten feet, in a slow, regular fashion, drawing the several boats after him with great ease. There were several harpoons in him, and one line was fastened through his tail and another to the dorsal fin.

"About half past five o'clock at night, he made his last circle in from the viaduct, and was directed over toward a sand-bank

FIG. 119. *Rhineodon typus.* MIAMI, FLORIDA.
Showing size of mouth. After Townsend (1913).

FIG. 120. *Rhineodon typus.* MIAMI, FLORIDA.
Showing great size and length.

by poking his head with a boat hook; he finally stranded on the sand-bank, and several lines, one around his body, were made fast to oars and boat-hooks stuck deep in the sand of the bank. A piece was then cut out of his head and with a knife, attached to a pole, it was sought to reach his brain and kill him. We were surprised to find about three inches of gristle at this point in his head.

"I had his measure taken while in the water on the bank, and he measured thirty-eight feet. A 20-foot line put around his body for the purpose of anchoring him to the sand-bank, lapped over about two feet, so that we judged that he was about eighteen feet in circumference. His weight was pure estimate, but we though he would weigh something over five tons.

"Next morning, which was Saturday, we brought the 'Samoa' up alongside, and lashed the fish to the side and started for Miami. That evening we reached a point opposite Railroad Camp, and went ashore to telegraph for a tug, and some of the railroad boys were very much interested in the catch. They thereupon, the next morning, which was Sunday, came out on a railroad tug, perhaps a dozen of them, and one of them took the pictures which are enclosed. We started on our journey to Miami and on Sunday afternoon were met by the tug and finally reached Miami about four o'clock Monday morning.

"The color was rather a mouse color, covered with yellow spots two or three inches in diameter, which were generally located in parallel lines of yellow, running from the backbone down each side. This marking is to some extent shown by the photographs. Underneath the color was yellow. The Captain put him on exhibition at Miami on our arrival, and at the time I left, several days later, he was making an effort to preserve him, having engaged the services of a taxidermist at Miami. He was successful in his attempt, as I have seen photographs of the mounted fish, and have heard of him through friends who have been in Miami the past season."[1]

[1]Through the kindness of Mr. John Mills of Miami, Florida, my attention has been called to an article on the Whale Shark in the *Wide World Magazine* for November, 1914, entitled, "Captain Thompson's Catch." This was written by Victor Pitt-Kethley and is so obviously intended for a "thriller" and is so highly colored as to have no scientific value, and attention is called to it here only to say so.

Figure 119 shows the Whale Shark, which had been hauled up alongside the yacht. Of especial interest are the enormous mouth in which a grown man is crouching, the small nasal apertures—the left one being immediately over the man's head—and the small eye immediately posterior to the angle of the jaw. This is one of the figures given in Doctor Townsend's article. This picture, together with a number of others, was taken by Mr. Joseph N. Beck, who later sold the negatives to Mr. Brooks. Mr. Brooks has sent me copies of all these photographs and through his kindness, I am able to give this picture and the two following.

Figure 120 gives an idea of the great size of this Whale Shark, for the tip of the tail may be seen just under the bow of the launch in the background of the picture. Note also the great size of the dorsal fin, and likewise the short transverse bars on the sides of the back. However, these are much better shown in Figure 121, the last of the pictures sent me by Mr. Brooks. Attention is also called to the first and second dorsal fins, and the upper lobe of the caudal, all of which are spotted.

With no small difficulty, even when aided by a tug, the great shark was finally brought to Miami. Here it was put on a marine railway and hauled up out of the water, but its weight (estimated at 5 tons[1]) was so great that it broke the timbers of the railway. Figure 122 is from a post-card presented me by Captain Thompson, showing this huge creature after it had been hauled out of water. In the right lower jaw, the band of teeth is plainly visible, and the nasal orifices and flaps are well shown. The left eye is in perfect focus, as are the spots which on the head are more numerous but smaller.

Back of the eye, and only about one-half the distance of this from the angle of the mouth, as it appears in Figure 122, may be seen the comparatively small spiracle which is here about three times longer than wide. It can also be made out on Figures 120

[1]This estimate is Mr. Brooks's, while that of Captain Thompson is three times as great. However, there is possibly a better way to get at it and that is by the fisherman's ancient formula, which I copy from C. F. Holder. This is that the length in inches multiplied by the square of the girth in inches and the product divided by 800 will give the weight in pounds. Taking the length at 38 feet (456 inches), estimating the girth at 18 feet (216 inches), and performing the operations designated, we get 26,594 pounds, or 13¼ tons for the weight of this giant shark.

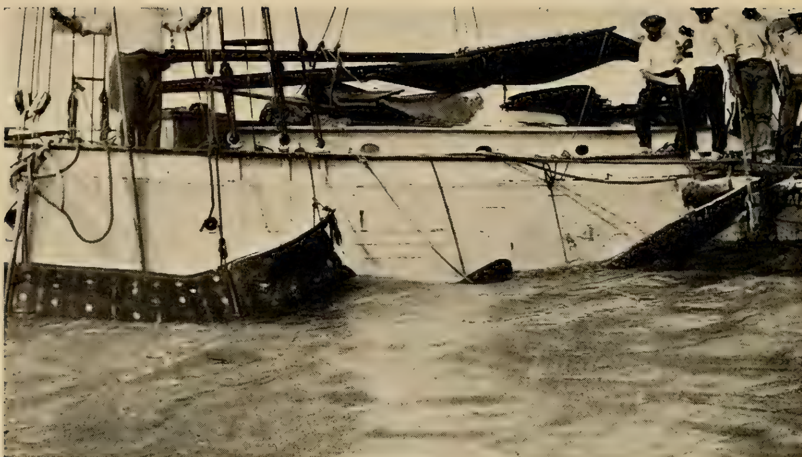

FIG. 121. *Rhineodon typus.* MIAMI, FLORIDA.
Showing dorsal fins together with spots and vertical bars.

FIG. 122. THE WHALE SHARK ON THE MARINE RAILWAY AT MIAMI.
To show mouth, teeth, nasal flaps, spiracle and gill-slits.

and 123. Back of the spiracle lie the enormous gill-slits which are also shown most plainly in Figure 122.

Figure 123 is made from a photograph of the mounted skin, and it shows how well Mr. Warmbath has done his work. Compared with Figures 120 and 121 made from photographs of the shark in the fresh condition, it would seem that the spots are too large. On the skin when seen by me in late July, 1912, the spots seemed about the size of a silver dollar, and were even then fading markedly.

It is a source of keen regret that I have not been able to examine this mounted specimen. A trip was contemplated to Atlantic City for this purpose, when it was learned that the specimen was in the Middle West. At last accounts it was on exhibition in Chicago.

Historical.

On a morning in April, 1828, some fishermen in Table Bay, Cape of Good Hope, South Africa, saw swimming leisurely around with its dorsal fin above water a large shark of unusual coloration. This was easily secured with the harpoon, since it offered comparatively little resistance, and was brought to shore where, fortunately for science, it fell in the hands of Dr. Andrew Smith, surgeon to the troops stationed in South Africa. Thus there came to the knowledge of the world the largest and in many ways the most interesting of the shark tribe.

During the following year (1829), Smith named his shark *Rhincodon typus* (evidently a misprint for *Rhineodon* as will be shown later), and gave a preliminary description of it as follows:

"Teeth slender, short, gently curved, so disposed in longitudinal rows that they have the form of a band in the front part of the maxilla and likewise in the similar part of the mandible; head wide, depressed, squarish, mouth at front of and almost as wide as the head; sides with longitudinal ridges and a very distinct keel on each side of the tail; a spiracle just behind each eye; anal fin almost opposite the second dorsal fin.

"Above, greenish-gray, with spots and numerous white lines; beneath, reddish-white, changing to red; with a dorsal keel before its anterior dorsal fin; behind, round, thence flat.

"Color of back and sides greenish-gray, with numerous white spots, varying in size from that of a sixpence to a half penny; also several white lines on the sides of the head, the body, and about the branchiæ; below, reddish-white, passing into vermillion red, anterior part of back carinated, posterior rounded or flat. Length of the specimen from which the description was taken, 15 feet; greatest circumference, 9 feet. Was caught by fishermen in Table Bay, during the month of April, 1828, and the skin was purchased for £6 sterling, and forwarded to the Paris Museum."

In 1841, Müller and Henle in their great "Systematische Beschreibung der Plagiostomen," an epoch-making work in the literature of the sharks and rays, give our fish a definite place under the name *Rhinodon typicus.* Their description is based on Smith's paper of 1829, and upon the dried skin in the Paris Museum. However, they give us one bit of information which Smith omitted, even from his second paper presently to be considered. They say: "The masculine appendages are in the single specimen small and do not extend backward past the hinder edges of the ventral fin."—i. e., this specimen was an immature male.

In 1849, Smith, in his "Illustrations of the Zoology of South Africa," published an elegant figure of our shark[1], which is reproduced herein as Figure 118 (frontispiece). He also redescribed the external features of the fish in the following words:

"Color.—The upper and lateral parts of the head and body dull lavender-purple, shaded with brownish-red; the under surface of the head, the sides of the body inferiorly, and the belly, light wood-brown, tinted with flesh-red, which tint is very strong on the anterior portion of the head and the hinder edges of the fin. On the upper and lateral parts of the head and body, and also on several of the fins, the ground-color is much broken by a profusion of small, circular white spots, and a great number of narrow vertical lines, which commence at the center of the back and terminate at the belly. The spots are smallest and most numerous on the head and upper surface of the pectoral fins, on the other parts they are larger and more scattered; and on

[1]The original figure in Smith's book has been colored by hand.

the caudal fin they are arranged in a single row close to its upper edge; the second dorsal, the anal, and the ventral fins are without spots. Eyes—coppery-red.

"Form, &c.—Head broad, depressed and somewhat wedge-shaped, the mouth opening directly in front; teeth small, recurved, closely congregated, and disposed in a broad, transverse belt along the inner surface of each jaw, immediately inside the lips; eyes lateral and situated almost directly behind the angles of the mouth; pupil transversely oval; temporal orifice about three-fourths of an inch in diameter. Vertical section of the body, in front of dorsal fin, somewhat triangular; and the back, between that fin and the middle of the hind head, slightly arched and strongly keeled; back, posterior to the dorsal fin, flat and depressed. Sides of body, irregular from two distinct longitudinal keels, which commence together a little in front of and considerably above the upper extremity of the first branchia, and recede a little from each other as they proceed backward. Of these, the lowermost pursues a waved direction, and at last is lost in, or coalesces with, the keel on each side of base of caudal fin; the upper again pursues a more direct course, becomes forked posteriorly, and both its branches terminate under and anterior to the second dorsal fin; the keel on each side of the tail very strong and thin at the outer edge. At the base of the upper lobe of the caudal fin, there is a transverse groove, to admit of the ready elevation of the fin, a power so necessary to direct the course of the fish in swimming. The first dorsal fin, posteriorly, is deeply emarginate, and the second dorsal fin has its inferio-posterior angle prolonged into a slender sharp point. Pectoral fins large, and their hinder edge, towards its base, with a distinct, large, triangular elongation. Ventral fins very small, and directly below the hinder portion of the first dorsal; anal fin also small, quadrangular, and with its superio-posterior angle prolonged into a point, its anterior angle directly under the hinder extremity of the base of the second dorsal. Caudal fin deeply forked, the upper portion larger and much longer than the lower. Branchiæ slightly waved, the first and second much the longest, and, together with the third, are in front of the base of the pectoral fins; the fourth and fifth are directly over it."

We next hear of our great shark in a letter sent from Dr. Buist in Bombay, to Colonel Sykes in London and published in Proceedings Zoological Society of London, 1850. Dr. Buist[1] in describing shark fishing at Kurrachee in Northwest India, west of the mouth of the Indus River, speaks of the capture of the "Great Basking Shark or Mhor," a giant shark "often 40, and sometimes 60 feet in length." Here the spots are not mentioned, but, as there is no record of *Selache maximus* being found in the Indian Ocean, we must conclude that *Rhineodon* is referred to. So think most of the writers on this fish.

Our next reference, however, is to a gigantic shark so well described that there can be no doubt as to its identity. Captain James Steuart in his "Notes on Ceylon," (1862), page 156, says: "Sharks of the ordinary description are frequently seen; and on two occasions my attention has been called to spotted ones of such monstrous size as to make the common ones at their sides appear like pilot-fish."[2]

The next describer of the Whale Shark is August Duméril (1865), who, however, had only the skin of the Table Bay specimen and Smith's descriptions to work upon. He gives a very clear and comprehensive description, but adds nothing to our knowledge save in the matter of teeth, which will be considered later.

In 1865, Doctor Theodore Gill described from the Gulf of California a spotted Whale Shark which, misled by Smith's description and Müller and Henle's erroneous figure of the teeth, he differentiated from the genus *Rhineodon,* while retaining it in the family *Rhineodontidæ,* under the name *Micristodus punctatus.* His statement (omitting the description of the teeth to be given later) is as follows:

"In the year 1858 the Smithsonian Institution received, from Captain Stone, the jaws and vertebræ of an enormous species of shark existing in the Gulf of California and known to the inhabitants of the neighboring regions as the 'Tiburon Ballenas,' or 'Whale Shark.' The specimen represented by the

[1] Doctor Buist's information came from a correspondent at Kurrachee.

[2] For a copy of this extract from Steuart I am indebted to the kindness of Mr. C. Tate Regan.

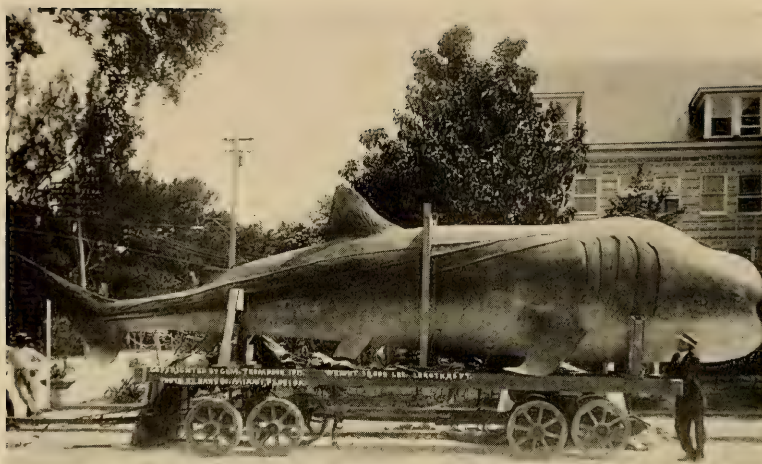

FIG. 123. MIAMI SPECIMEN AFTER MOUNTING.
After Townsend (1913).

FIG. 124. MADRAS MOUNTED SPECIMEN OF THE WHALE SHARK.
After Thurston (1894).

spoils was said to have been '20 feet long,' with a 'head, six feet wide,' 'pectorals, 3 feet long' and 'flukes, six feet between tips.' 'The back from the head to the first dorsal fin, brown, with reddish spots.' The head is represented as truncated in front.

"This type will be seen, therefore, to be very distinct, but is evidently related to the South African genus *Rhinodon,* and must be referred to the family of *Rhinodontidæ* with the name of *Micristodus punctatus.*"

Jordan and Evermann (1896) copy Gill without being able to add anything to our knowledge, since, when they wrote, no other specimen had been taken on the west coast of North America and so far as the present writer knows this statement holds good to the present time.

In 1902, Mr. B. A. Bean published in *Science* a note on the coming ashore at Ormond, Florida, of an 18-foot *Rhineodon,* and in this referred to Doctor Gill's *Micristodus.* A few weeks later Doctor Gill, in the same journal, after comparing the teeth of the Floridan and Californian specimens, declared them to be at least congeneric. To this conclusion Günther (1884) had already come.

We now come to E. Perceval Wright, a naturalist whose opportunities for the study of the Whale Shark have been greater than those of all scientists from Smith in 1829 to the present writer in 1913, all added together, and who has in comparison made less use of them than any one else. In justification of this severe criticism, let us see what opportunities he has had and what he has done with them. Writing from the Seychelles, a group of islands in the western Indian Ocean northeast of Madagascar, he says in 1870.

"It was between this island and the eastern coast of Mahé that I had the good fortune to meet with the 'Chagrin.' I had often heard stories of this monstrous fish; but at first I attached as little credit to them as I do to the stories told by Bishop Pontoppidan about the 'Kraken'; however, Mr. [Swinburne] Ward having measured one that somewhat exceeded 45 feet in length, I felt bound to believe this evidence, longing all the while to corroborate it by my own personal experience. This I was able to accomplish, and, thanks to Mr. Ward's exertions, and to the offer of a reward of twelve dollars for the first specimen suc-

cessfully harpooned and brought to shore, I was enabled to take photographs of two specimens, male and female, of this remarkable shark, and to preserve all the more important portions of each for a more careful examination in Dublin. This shark, which is—the north whale excepted—the largest of living animals, would appear to have a very limited geographical distribution, and, contrary to the general habits of the true shark, it is not a carnivorous but a herbivorous fish. I have seen specimens that I believed to have exceeded fifty feet in length, and many trustworthy men, accustomed to calculate the length of the sperm whale (one of the most important stations for this cetacean is off Ile Denis, one of the Seychelles Group) have told me of specimens measuring upwards of seventy feet in length; it is a quiet, harmless fish, with a mouth of immense width, furnished with small teeth; it now and then rubs itself against a large pirogue, and as a consequence upsetting it, but under such circumstances it never attacks or molests the men, and while it reigns as a monster among sharks, is not, despite its size, as formidable as the common dog-fish. A stray specimen, about seventeen feet long, was found many years ago floating near Capetown, and was named by Sir A. Smith, *Rhinodon typicus,* but it would appear that nothing more has until now been known about this fish."

In his *Catalogue of Fishes in the British Museum,* Volume VIII, (1870), Günther quotes all the preceding writers, especially Wright, who had presented part of a pair of jaws to the Museum, but adds no new data.

Much of Wright's data is repeated in a paper published in 1877, and in his book, *Animal Life,* published in 1879. Now it will be noticed that Wright says that these sharks were common at the Seychelles. He saw at least four of them, he photographed two, and dissected at least two, and sent parts to Dublin for further study; but he never published his photographs, and never described any of the external or internal structures of the fish. To make sure of these points, I addressed a letter to the Librarian of Trinity College, Dublin, asking about these preserved parts.

This letter was answered by Doctor Henry H. Dixon, Professor of Botany in Trinity College, who kindly writes that nei-

ther preserved material nor photographs of Wright's specimens are known at the College. Dr. Dixon notes that Wright apparently made a report at the 1869 meeting of the British Association under the title, "*Rhinodon typicus,* the largest known shark," but that this was never published. Further than this, neither he nor Mr. Alfred de Burgh, assistant librarian, working from the published bibliography of Wright's papers, have been able to find any further published data. It is a great loss to science that Wright made so little of his extraordinary opportunities.

In his "Introduction to the Study of Fishes" (1880), Günther gives a very general description of the Whale Shark based evidently on Smith's and Wright's papers. There is nothing in it to detain us, since the new bit of data refers to its food and will be considered later.

In the *Annals and Magazine of Natural History* for 1883, A. Haly, director of the Colombo Museum, records the capture of a *R. typus* near Colombo, Ceylon, in 1883. This was a female, 23 feet 9 inches long, and 13 feet in circumference, having a mouth 3 feet wide. Before drying had taken place, the lower jaw was flat underneath, grading without break into the abdomen, and projecting so far beyond the upper that its band of teeth was uncovered. Haly dissected this specimen hoping to find eggs or embryos but found her barren. Unfortunately he gives no description of the reproductive organs. His careful measurements will be given later.

In the following year, Haly (1884) in his report for 1883 as director of the museum, says that this fish was taken at Moratuwa on January 5, 1883, and that its weight was so great that even after the viscera had been removed, it was handled only with the greatest difficulty. It was too large to be taken into the museum after mounting, so it was necessary to convert the main hall of the museum into a taxidermist's room.

The next reported capture of the Whale Shark is in 1884 by Signor G. Chierchia, whose interesting account is quoted *in extenso* from *Nature.*

"While fishing for a big shark in the Gulf of Panama during the stay of our ship in Taboga Island, one day in February (1883), in a dead calm, we saw several great sharks some miles

from our anchorage. In a short time several boats with natives went to sea, accompanied by two of the Vettor Pisani's boats.

"Having wounded one of these animals in the lateral part of the belly, we held him with lines fixed to the spears; he then began to describe a very narrow curve, and irritated by the cries of the people that were in the boat ran off with moderate velocity. To the first boat which held the lines just mentioned other boats were fastened, and it was a rather strange emotion to feel ourselves towed by the monster for more than three hours with a velocity that proved to be two miles per hour. One of the boats was filled with water. At last the animal was tired by the great loss of blood and the boats assembled to pull in the line and tow the shark on shore.

"With much difficulty the nine boats towed the animal alongside the Vettor Pisani to have him hoisted on board, but it was impossible on account of his colossal dimensions, but, as it was high water, we went to a sand beach with the animal and we had him safely stranded at night.

"With much care were inspected the mouth, the nostrils, the ears and all the body, but no parasite was found. The eyes were taken out and prepared for histological study. The set of teeth was all covered by a membrane that surrounded internally the lips; the teeth are very little and almost in a rudimental state. The mouth, instead of opening in the inferior part of the head as in common sharks, was at the extremity of the head; the jaws having the same bend.

"Cutting the animal on one side of the backbone, we met (1) a compact layer of white fat 20 centimeters deep; (2) the cartilaginous ribs covered with blood vessels; (3) a stratum of flabby, stringy, white muscle, 60 centimeters high, apparently in adipose degeneracy; (4) the stomach.

"By each side of the backbone he had three chamferings or flutings, that were distinguished by inflected interstices. The color of the back was brown with yellow spots that became close and small toward the head, so as to be like marble spots. The length of the shark was 8.90m. from the mouth to the pinna caudalis extremity, the greatest circumference 6.50m., and 2.50m. the main diameter (the outline of the two projections is made for giving other dimensions).

"The natives call the species tintoreva, and the most aged of the village had only once before fished such an animal but smaller. While the animal was on board, we saw several *Remora* about a foot long drop from his mouth; it was proved that these fish lived fixed to the palate, and one of them was pulled off and kept in the zoological collection of the ship."

This description was sent by Chierchia to Günther who, in the same number of *Nature,* commented most interestingly on *Rhineodon.* In addition to the occurrences hitherto noted Günther says that in 1878 Professor W. Nation examined a specimen taken at Callao, Peru, and sent a portion of the dental plate to the British Museum. Being unable to run down this reference, I referred it to my friend, Mr. H. M. Lydenberg, Reference Librarian of the New York Public Library, who kindly informs me that Nation had his headquarters at Lima and that he was a corresponding member of the Zoological Society of London. However, in none of the publications of the Society about this time, nor in the Royal Society Catalogue is there reference to any paper on *Rhineodon* by Nation.[1]

In *Elements of Zoology,* by C. F. and J. B. Holder (1884) there is a very crude figure of the Spotted Whale Shark. In fact, it is mottled rather than spotted, is devoid of keels and cross-bars, and in general is so imperfect that it does not seem necessary to reproduce it here.[2] In the following year (1885) Doctor C. F. Holder published his interesting book, *Marvels of Animal Life,* in which he gives some data concerning our fish, mainly taken from Wright but in part descriptive of the Ceylon specimen—the latter data communicated to him by Colonel Nicolas Pike, who had visited Ceylon the previous year.

[1]Since writing the above, I have accidentally found (Jan. 2, 1915) that Nation published his account in the *South Pacific Times* issued at Callao on Jan. 24, 1878. This journal is not to be found in either the Library of Congress, the New York Public Library, or the Library of the British Museum, and as there is not time to get a transcript from Callao, it is impossible to give Nation's description here.

[2]By an interesting coincidence, while reading the third proof of this article, the original drawing of this figure has been received. For it I am indebted to the kindness of Dr. C. H. Townsend who found it in the library of the New York Aquarium. The published reproduction in Holder's book is the first figure I ever saw of the Whale Shark.

The figure in his book is, like the preceding, more or less the product of the fancy of the artist and calls for no reproduction.[1]

In his report of the Colombo Museum for 1889, Haly (1890) notes the capture at Negombo, Ceylon, earlier in that year, of an 18-foot specimen. The skin of this specimen was presented to the British Museum where it was mounted and is now on exhibition. It is presumably the skin elsewhere referred to as mounted by Gerrard.

In 1894, Edgar Thurston, of the Madras Government Museum, published the following interesting account of specimens from Ceylon and the east coast of India.

"While in Colombo I took the opportunity of examining the excellently preserved specimen of *Rhineodon typicus* in the Ceylon Government Museum for the sake of comparison with the specimen, 22 feet in length from the end of the snout to the extremity of the tail, which was cast on shore at Madras in February, 1889, when I was unfortunately far away from head-quarters, so that the chance was missed of examining its stomach contents and internal anatomy. The telegram which reached me announcing the arrival of the monster ran as follows:—'Whale on shore. Stupendous spectacle.' But, on the following day, I learnt, from the evidence of an expert, that the whale was a shark. As the following extract shows, but few specimens of this gigantic elasmobranch have been recorded."

The "extract" referred to gives a résumé of the work of Smith, Wright, and Haly, and notes that the latter succeeded in obtaining several specimens. One of these was the 1889 specimen which was presented to the British Museum. This, it is stated, has been mounted by Gerrard, and though only a small specimen 17 feet long, makes a striking object in this great museum. In a foot-note we read that in April, 1890, another small specimen 14½ feet long was taken off Bambalapitiya, Ceylon.

Who the author of the above "extract" is, I have been unable to ascertain. The figure of the Madras mounted specimen is

[1]In a personal letter to the present writer, Dr. Holder says that these figures are the work of artists employed by the publishers and for which he is in no wise responsible.

herein reproduced as Figure 124. The dimensions of this shark will be given in the section on size.

In his *New Natural History,* Vol. V (1901), Richard Lyddeker, under the heading "Basking Shark, *Rhineodon typicus,*" gives some general data, and his figure on page 2903 is only a fair adaptation of Smith's figure (1849).

In the *Zoologischer Anzeiger,* 1901, Kamakichi Kishinouye of the Imperial Fisheries Bureau, Tokyo, Japan, gives a descrip-

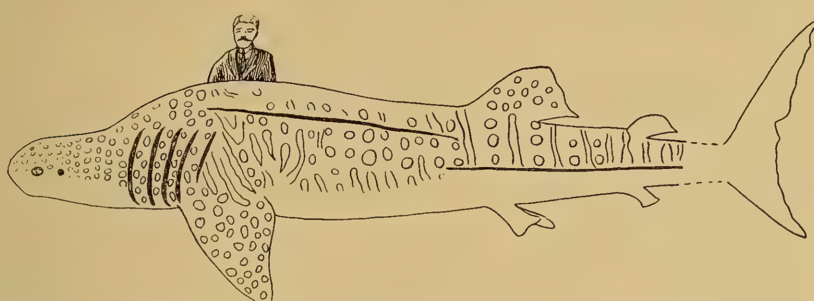

FIG. 125. LATERAL VIEW OF *R. pentalineatus* (Figure 118). After Kishinouye (1901).

tion of what he makes out to be a new species of *Rhineodon.* However, Doctor Gill (1902) thinks it *R. typus.* Omitting the description of the teeth (to be given later), the following is the interesting account of this fish given by the Japanese ich-

FIG. 126. FRONTAL VIEW OF *R. pentalineatus* (Figure 119). After Kishinouye (1901).

thyologist, while Figures 125 and 126 are lateral and frontal views copied from his paper:

"On 10th of June, 1901, a rare and gigantic shark was caught by drift net off Cape Inubo. Mr. Tsuratame Oseko who keeps

a collection of rare things for show in Asakusa Park, Tokyo, bought the fish and brought its skin to Tokyo to be stuffed, notwithstanding many difficulties accompanying its enormous size and ponderous weight. The external part is complete, except the portion between the anal fin and the caudal.

"The general appearance of the fish is very ugly, with the flat and blunt head, straight, terminal mouth and the small eyes. The skin is fine-grained, except five longitudinal smooth bands, one dorsal median and two pairs lateral. The ventral lateral band seems to be continuous to the keel on each side of the tail (Fig. 118).

"The eye is very small, situated at the sides of the head near the margin of the colored portion of the head. The nictitating membrane wanting. The spiracles are nearly the same in size and are on the same level with the eyes. The nostrils are at the anterior extremity of the head. They open at the labial boundary of the mouth.

"The mouth is nearly straight and opens at the anterior extremity of the head, too. A labial fold from the nostril to the corner of the mouth on the upper jaw and a shorter one from the corner of the mouth on the lower jaw. (Fig. 119.)

"The gill openings are five in number and are very wide. The second pair is widest and measures 86 cm. The last pair is most narrow, it opens above the base of the pectoral fins, where the body is very broad and high. The pectoral fins are large and long. The first dorsal fin is inserted a little behind the middle of the body. The second dorsal fin is very small. The ventral fins are inserted below the first dorsal. The clasper is simple, with a dorsal groove. The anal fin is very small. It is just below the second dorsal. The caudal fin is large and lunate. Its ventral lobe is well developed.

"The color is greyish-brown, with white round spots and transverse bands, but the ventral side is colorless. The white round spots are small and crowded near the anterior end of the body, but become gradually larger and fewer backwards. The caudal fin, the second dorsal, the ventrals and the anal, are destitute of white markings.

"The stuffed animal now measures 800 cm. in length and 365 cm. in circumference, behind the pectorals. Mr. Oseko tells me

that the skin has shrunk much and that the fish measured nearly 1000 cm. when fresh. He says, moreover, that the shark was covered with many sucking fishes and one of these fishes and a pole made of oak (ca. 30 cm. long) were found in the stomach.

"Though the hitherto-known allied species (*Rhineodon typicus* Smith and *Micristodus punctatus* Gill) are described insufficiently, I am inclined to believe that this fish is a new species of the *genus Rhinodon,* as it differs from these species in the form of teeth and the labial fold. Hence, I propose the name of *Rhinodon pentalineatus* for this species."

Jordan and Fowler (1903) list this shark in their "Elasmobranchiate Fishes of Japan" on the basis of Kishinouye's description.

On page 88 of his *Introduction et Description de l'Expedition* (Siboga), Max Weber (1902) records the fact that, while in the strait between Buton and Muna, Celebes Islands, East Indies, several examples of the Whale Shark were seen but none could be captured.

In his description of the fishes of this expedition (vol. 57 of *Siboga Expeditie,* p. 594), Weber says that these gigantic sharks swam around the vessel so closely that they were easily recognizable, but that, when an effort was made to capture them, they sank out of sight.

In *Science* for February 28, 1902, Mr. B. A. Bean, Assistant Curator of Fishes in the United States National Museum, records the stranding on the shore near Ormond, Florida, of an 18-foot specimen of *Rhineodon typus.* This is the first record of the occurrence of this rare shark on the eastern coast of America, and, in fact, its first known occurrence in the Atlantic Ocean. Its skin is now among the treasures preserved in the National Museum at Washington.

In the issue of *Science* for May 23, 1902, there appeared an exceedingly interesting article entitled "The Whale Shark (*Rhinodon typicus*) as an American Fish," from the facile pen of Dr. Theodore Gill. In this Dr. Gill gives a valuable résumé of a good portion of the known references to this rare fish, and concludes by conjecturing that the American forms may possibly be of a distinct species entitled *Rhineodon punctatus.*

Bridge (1904), in *The Cambridge Natural History,* Vol. VII, on page 454, gives a very general account of the *Rhinodontidae,* but adds practically nothing to our knowledge.

Again in *Science* under date of May 19, 1905, Dr. Gill summarizes some additional data bearing especially on the habits of the Whale Shark which he here calls *Rhineodon typus.* I take occasion here to acknowledge my indebtedness to these two articles of Dr. Gill and for data which he gave me personally.

A few weeks after the appearance of Dr. Gill's last note, Mr. Barton A. Bean published his valuable *History of the Whale Shark* in Smithsonian Miscellaneous Collections. This paper, giving a considerable number of verbatim quotations and being finely illustrated, has been of much help in the preparation of this article.[1]

In his paper Mr. Bean gives careful measurements of the Ormond, Florida, specimen, which will be reproduced later; he also gives a careful description of the teeth which will be referred to in the section on mouth and teeth. The skin of this 18-foot specimen was a dark brownish-grey, while the carinations were of a light chocolate color. The spots on the body were comparatively few, but large, while on the head they were smaller but in much greater numbers. The transverse light-colored bands were absent, strange to say, though probably they had faded out of the dried skin. Underneath the body was light colored. Fig. 127 is the elegant frontispiece to Mr. Bean's paper.

In the same year (1905) Jordan's *Guide to the Study of Fishes* appeared. On page 540 of Vol. I there is a paragraph given to the *Rhinodontidæ,* but there is no new data whatever.

In 1908, Lloyd records the capture of a small specimen at the mouth of the Hooghly River at the head of the Bay of Bengal in 26½ fathoms of water. This fish was 14 feet long, 4 feet wide across the nose and 3½ feet across the mouth. The girth around the head was 8½ feet, and around the belly 9½. Its color was a "dark bluish grey with large irregular paler blotches." The small teeth were in bands in each jaw, 350 rows of about 10 teeth to each row in a band, or about 7,000 in all.

[1]To the officials of the Smithsonian Institution I am deeply indebted, not merely for permission to copy the figures in Mr. Bean's paper, but for the use of the blocks themselves.

The occurrence of *Rhineodon* in the Java Sea is recorded by Van Kampen in 1908. On May 7 fishermen harpooned in Batavia Bay and brought to the fish market in Batavia a specimen 5.75 metres long (about nineteen feet). Van Kampen dissected this specimen but gives no account whatever of its internal organs.

Weber (1913) relates that Van Kampen showed him a beautiful photograph of a specimen which he thinks was probably caught in Madura Strait (north coast of Java) and photographed while fresh in the harbor of Surabaia. Unfortunately Van Kampen does not seem to have written up this specimen.

Dr. H. M. Smith in 1909, in an interesting paper entitled "Some Giant Fish of the Seas," gives only general data but a fine picture of the Whale Shark in the act of diving. Two years later before the Biological Society of Washington he made known the occurrence of this fish in the Philippine waters. His report, as it appears in the *Proceedings* (1911) will now be summarized.

In the issue of the *Philippine Free Press* of September 10, 1910, there is published a photograph with brief description of a marine monster from one of the islands, Negros Occidental by name. Throughout the article the animal is called a whale, but the photograph shows it to be a Whale Shark. It was about eighteen feet in length and was caught in a fish trap near Bacolod on September 4, 1910. This is the first capture, so far as known, that has been made in the waters of our western possessions.

Notices of the notes by the present writer (1913), Dr. Smith (1913) and Dr. Townsend (1913), on the Miami, Florida, specimen of 1912, have already been given in the first section of this paper, and need not be repeated here.

It seems that in *The Fishing Gazette* (London) early in May, 1913, there was published a reproduction of one of the postcard figures of the Miami specimen with a lot of nonsense about its being an unknown and unclassifiable monster. In the issue of that journal for May 24, Mr. C. Tate Regan of the British Museum replies in an interesting little article under the heading "The Largest Shark." In this he gives some brief quotations

from Wright and others, with a line drawing reproduction apparently of Thurston's figure of the Madras specimen.

The above called forth a letter from Mr. A. J. Boland in the next issue of the same journal in which he speaks of having seen in the Colombo Museum in 1903 a fine specimen of the great spotted shark. This he thought to have been from 30 to 35 feet long. "Around it were placed ordinary sharks, which looked like parr to salmon in comparison.[1]

Habitat.

This singular fish seems to be solitary in habit but of wide distribution. It was first reported from Table Bay, Cape of Good Hope, by Smith in 1829. Next Buist (1850) writes of a giant shark frequently captured at the head of the Arabian Sea at Kurrachee, west of the mouth of the Indus. Later Steuart (1862) reports it as not uncommon around Ceylon, as does Haly (1883, '84, '90), and Thurston (1894), while Shipley and Hornell record it in 1905.

Gill (1865) records a specimen taken in the Gulf of California about 1858. While Wright notes it as abundant at the Seychelles about 1869, as does Pike (1873) quoting from the notes of Swinburne Ward. Next we hear from Chierchia (1884) of its capture in Panama Bay, while in the same article Günther reports that Nation in 1878 had examined one at Callao. Next, omitting Thurston's Ceylon notes (1894) already referred to, but recalling the 22-foot specimen that he found ashore near Madras in 1889, we find this fish reported on the coast of Japan by Kishinouye in 1901. The following year (1902) Bean recorded its first occurrence in American waters and indeed in the Atlantic Ocean.

In 1902, Weber saw several in the Java Sea, while six years later Van Kampen recorded it in Batavia Bay, and in 1913 Weber refers to its capture on the north coast of Java. In 1908 Lloyd records its first known occurrence in the Bay Bengal. Its first appearance in the Philippines, so far as known, was noted by Smith in 1911. And its latest occurrence, and the second in

[1]For copies of the Gazette containing these articles, I am indebted to the courtesy of Dr. C. F. Holder.

our waters, is that of the Florida Keys specimen, for which data have been given in 1913, by Gudger, Smith and Townsend.

Through the kindness of Col. C. R. M. O'Brien, C. M. G., governor of the Seychelles, and of Mr. P. R. Dupont, Curator of the Botanical Station at Mahé, I have received information (December 8, 1914), that the "chagrin" is very common about the Seychelles throughout the year. Mr. Dupont writes that he has come across several himself, that the fishermen report that the smallest seen measures about 20 feet long, and that they come in shore when shoals of a Caranx make their appearance.

Thus we see that this huge but very rare fish, so far from having a restricted distribution, has an extraordinarily wide one. While found in the Atlantic, and not altogether infrequent in the Pacific, its especial habitat seems to be in the Indian Ocean and the waters contiguous thereto.

Size.

In size this fish varies greatly. Lloyd's specimen (the smallest ever taken) was 14 feet long and 9½ feet in girth. Smith's Table Bay specimen was 15 feet long and 9 feet around. Buist's figures make this shark 40 to 60 feet in length, the mouth being sometimes 4 feet wide. Steuart's sharks were of such enormous bulk that they made ordinary sized sharks look like pilot-fish. Gill's Gulf of California shark was 20 feet long. Wright dissected an 18-foot specimen. His friend, Swinburne Ward, measured one over 45 feet in length, while he himself saw specimens exceeding 50 feet, and "heard of some individuals—of about 70 feet in length." These latter were reported to him by the whale fishers of Saint Denis, "trustworthy men accustomed to calculate the length of the sperm whale."

Haly's 1883 specimen measured 23 feet 9 inches over all and 13 feet in girth behind the pectorals and had a mouth 3 feet wide, while that of 1890 was 5 feet shorter (18 feet). Chierchia in the Bay of Panama in 1884 "saw several great sharks some miles from our anchorage." The one captured was about 29 feet long over all and about 21 feet in circumference—an extraordinary girth for the length, the former generally being about one-half the latter. According to Thurston, the Madras specimen while fresh was 22 feet long, but the girth was not taken,

while a little one captured near Bambalapitiya, Ceylon, in 1880, was only 14 feet 6 inches in length. Kishinouye's specimen, named by him *R. pentalineatus,* when stuffed measured 26 feet in length and about 12 feet in circumference, but is reported to have been nearly 33 feet long when fresh. Bean's Florida specimen was 18 feet over all. Van Kampen's Batavia Bay fish was nearly 19 feet long, while the Philippine specimen recorded by Smith was slightly over 20 feet in length. The second Florida specimen was 38 feet long and as near as could be gotten about 18 feet in girth according to Mr. Brook's letter quoted above.

Fairly complete sets of measurements have been given for four fish as shown on the following page.

Color.

According to Smith, the discoverer of this fish, the color was above greenish-gray varying to dull lavender-purple and shaded with brownish-red; below reddish-white, becoming redder on edges of fins and under the head. The upper and lateral parts of the body were covered with white spots, smaller and more crowded on the head and adjacent parts, larger and more scattered behind, with narrow vertical white lines running from back to belly. See Figure 118.

Gill's specimen from the Gulf of California was brown with reddish spots above. Wright, notwithstanding his magnificent opportunities, has given us no description of the Seychelles form. Chierchia notes that his Panama Bay specimen was brown above with yellow spots so close and small on the head as to give it a marbled appearance.

Kishinouye found the Japanese fish to be grayish-brown above with round white spots and with vertical bars, while below it was colorless. As to size and number of spots he is in agreement with the other describers.

The first Florida specimen was a dark grayish-brown with large spots, while the keels were a light chocolate, but there were no vertical bars. These had probably faded out. For this fish see Mr. Bean's elegant Figure 127.

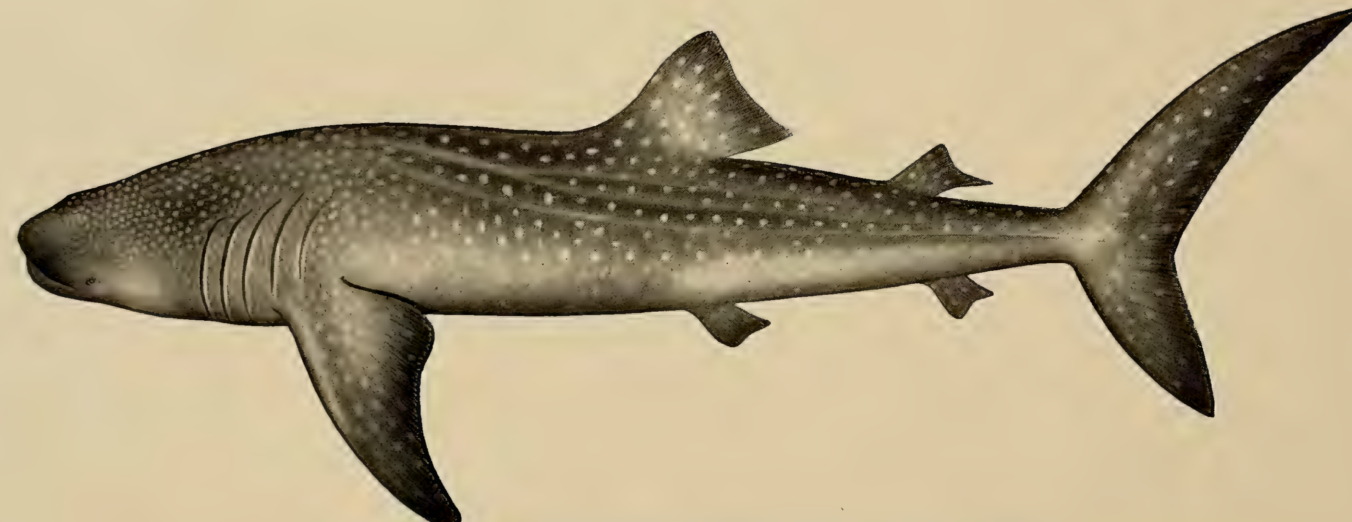

FIG. 127. WASH DRAWING OF RHINODON STRANDED ON COAST OF FLORIDA.
Made from the skin and photographs by Mr. A. H. Baldwin. After Bean (1905).

MEASUREMENTS OF THE WHALE SHARK.

Measurements of *Rhineodon typus*	Smith, Table Bay, 1829-1849		Haly, Ceylon, 1883		Thurston, Madras, 1894		Bean, Florida, 1905	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Length over all	16	6	23	9	22	0	18	0
Girth of body behind pectorals	9	3	13	0				
Girth of body one foot behind pectorals	8	5						
Distance from mouth to base first dorsal	8	6	10	0	9	10		
Distance from first to second dorsal	2	0	2	8	2	3		
Distance from second dorsal to root caudal fin	1	8						
Distance along upper lobe of caudal	4	0	5	0	5	0	3	6
Distance along lower lobe of caudal	2	10	2	7	2	6		
Distance along anterior edge first dorsal			1	10	1	10		
Distance along base of first dorsal			1	10	2	0	1	5
Height first dorsal	1	3						
Distance along anterior edge second dorsal		11		11½		11		
Distance along base of second dorsal		11		11½		7		
Length of pectoral fin	3	2	3	6	3	2	3	1
Breadth of pectoral fin along base	2	0			1	8	1	6½
Length of anal fin		9						10
Breadth of anal fin along base		9						6½
Length of ventral fin along anterior edge	1	0						10
Breadth of ventral fin along base	1	0						9½
Width of mouth	2	8	3	0	2	6		
Width between nostrils							1	9
Width of head one foot in front of first gill-slit	3	8½						
Diameter of eye				1½		1½		¾
Diameter of spiracle				1½		1x⅜		1½
Distance between eye and spiracle		4½				4		
Distance between tip of snout and eye		6				10		
Distance between tip of snout and first gill-slit	2	10			3	4		
Length of first gill-slit					1	11	1	6
Length of second gill-slit			2	7	1	11½	1	8
Length of third gill-slit					1	9	1	7
Length of fourth gill-slit					1	8	1	4
Length of fifth gill-slit					1	7	1	1

Of the second Florida specimen, Mr. Brooks says that while fresh: "The color was rather a mouse color, covered with yellow spots two or three inches in diameter, which were generally located in parallel lines of yellow, running from the backbone down each side. Underneath the color was yellow." In this connection see the various figures reproduced from the photographs loaned me by Mr. Brooks. These show the markings, especially in the region of the first dorsal fin, admirably.

After reading the above descriptions of the marked colors of these various specimens, one wonders why so eminent an ichthyologist as C. Tate Regan should say (1908): "As a rule the pelagic forms (. . . . *Rhinodon*). . . . have no conspicuous markings."

Jaws and Teeth.

The jaws are enormously large, the teeth almost microscopically small. Smith, the discoverer of the fish, says in his first paper (1829): "Teeth short, slender, gently curved, so disposed in longitudinal rows that they have the form of a band in the front part of the maxilla, and likewise in the similar part of the mandible."

Müller and Henle were the first scientists to examine Smith's specimen after its deposit in the Museum of Paris. Of it they say (1841): "Teeth extraordinarily small, conical, very numerous, card-like in arrangement. The conical teeth, with points somewhat curved backward, were in a 15½-foot specimen scarcely a line (1/12 inch) long. They stand in 12 to 15 rows one behind another, about 250 to a row." Their figure of

FIG. 128. TEETH OF *Rhinodon typicus.*
As represented by Muller and Henle.
After Bean (1905).

the teeth is given herein as number 128. This is from their plate 35 which also contains a semi-diagrammatic section of the tooth band. This contains fourteen rows, each having 19 teeth. Fourteen rows with 250 teeth to a row would give a total to each

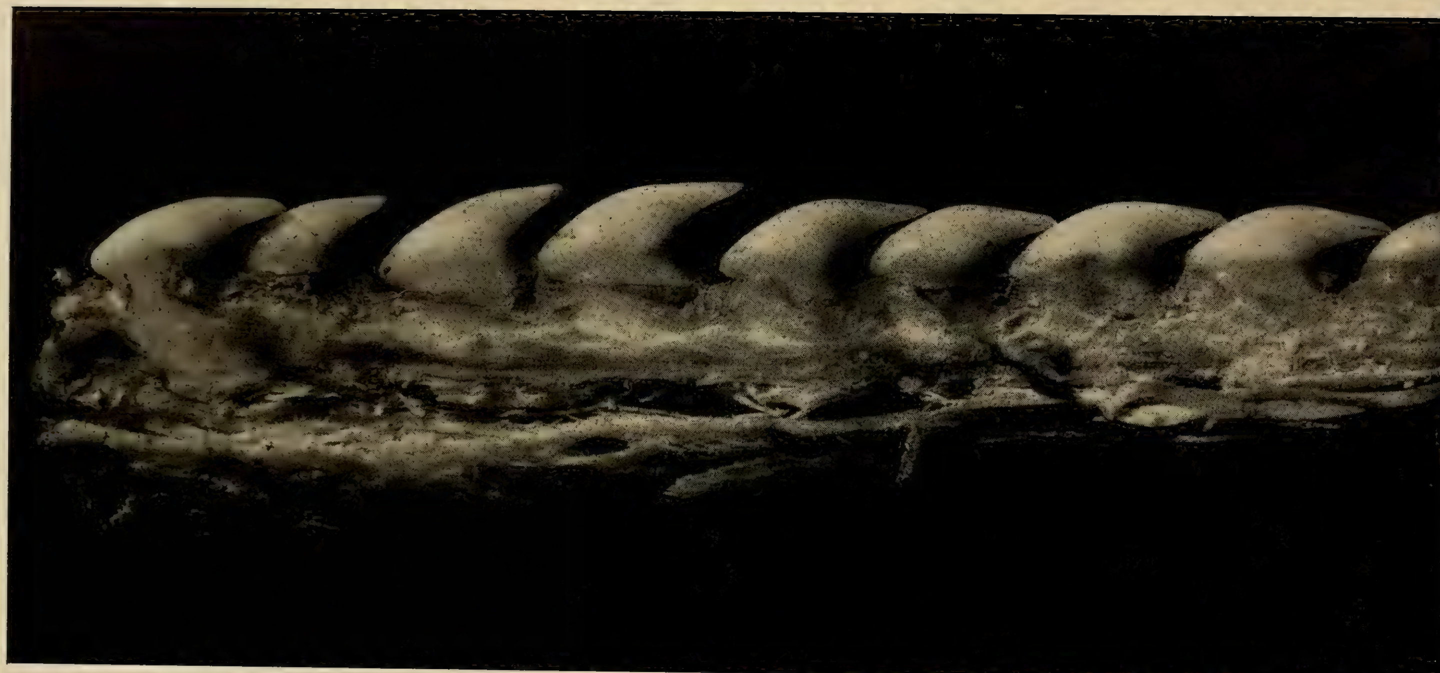

FIG. 129. PHOTOGRAPH OF VERTICAL ROW OF TEETH.
From dental plate of *Micristodus punctatus* Gill. (Twelve times enlarged). After Bean (1905).

jaw of 3500 teeth, if 15 rows, then 3750 teeth. Later it will be shown that both their description and their figure of the teeth are alike erroneous.

In his fuller paper (1849) Smith merely says: "teeth, small, recurved, closely congregated, and disposed in a broad, transverse belt along the inner surface of each jaw, immediately inside the lips." While of the Arabian Sea specimen Dr. Buist (1850) does nothing more than state that in the "Mhor" the mouth sometimes reaches a width of 4 feet.

In 1865 August Duméril after examining the Table Bay specimen gives as the characters of the family *Rhinodontidae*:

"Teeth exceedingly small and very numerous, analogous to the teeth of a card which are very fine and bent backward, and comparable to the brush-like teeth of certain teleosts, forming a band rough to the touch on each of the jaws on which the band is interrupted in the region of the median line."

While under the heading, *R. typicus,* he thus specifies:

"The band of teeth is formed by 12 or 15 transverse rows of teeth, having a width of about 0 m. 0 3. In a square of 0 m. 0 3. on each side are found 17 teeth in 12 rows each or 204 teeth. Now the two jaw bands form together, deduction being made for the median spaces, a length of one metre (.45 above, and .55 below), 33 squares of 0 m. 0 3. on each side, or 33 times 204 equals to at least 6732 teeth. This number is considerably larger than that given by Müller and Henle, who counted 12 to 15 rows of 250 teeth each, a number evidently too small, and who got only 3750 teeth" [in each jaw, a point Duméril overlooked].

Dr. Gill, in the same year (1865), in writing of the form from the Gulf of California, says:

"The dried dentigerous band of the upper jaw is slightly curved forward, about 19 inches between the extremities, and somewhat more than an inch in width in front. The teeth are fixed and extremely minute, the largest being little more than a line in length, and decrease toward the ends of the jaw; they are disposed in regularly transverse rows, of which there are over one hundred and sixty (164-167) on each side, while in front there are from thirteen to sixteen in each transverse

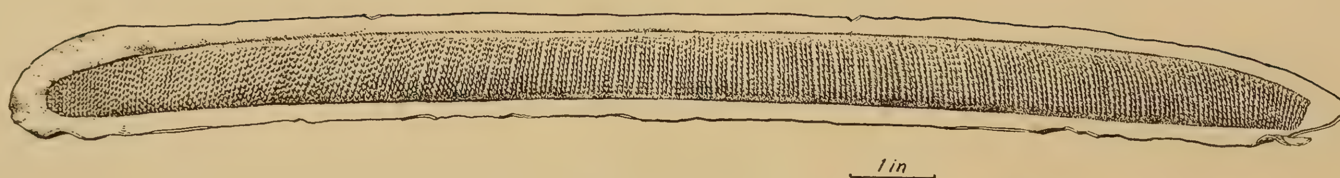

FIG. 130. DENTAL PLATE OF UPPER JAW OF ORMOND, FLORIDA, SPECIMEN.
After Bean (1905).

row; each tooth is recurved backwards and acutely pointed, swollen and with a heel-like projection in front rising from its base."

How accurate is Dr. Gill's description may be judged from the accompanying Figure 129 of the teeth of this specimen which is here copied from Mr. Bean's 1905 paper:

Wright speaks of the Seychelles "Chagrin" as having "a mouth of immense width, furnished with small teeth." Here it will be well to recall Buist's statement that the Kurrachee specimens had mouths 4 feet wide, while that of Haly's Ceylon fish was 3 feet across. Of the teeth, Haly writes (1883):

"When fresh, the lower jaw was quite straight and flat, nearly, if not quite, on a level with the surface of the abdomen, and considerably in advance of the upper, so that the band of teeth in the lower jaw was quite uncovered. This band averages one inch in breadth [in a 23-foot, 9-inch specimen], and consists of 14 rows of minute, sharp, recurved teeth, 2 mm. long, all of equal size. The band in the upper jaw is ¾ inch broad, and consists of 11 rows of similar teeth."

Chierchia merely says of the Panama specimen: "The set of teeth is all covered by a membrane that surrounded internally the lips; the teeth are very little and almost in a rudimentary state."

Nation sent a portion of the jaw of the Callao specimen to the British Museum. This was examined by Günther and the teeth compared with those of Ward's specimen from the Seychelles. Günther writes (1884): "The teeth differ in no respect from those of a Seychelles Chagrin; they are conical, sharply pointed, recurved, with the base of attachment swollen." This is the first detailed description of the teeth of *R. typus,* and so like Gill's account of the dental armature of *Micristodus punctatus* that Günther unhesitatingly declares them to be identical. (Here see Figure 129.)

Thurston says of the specimen in the Colombo Museum: "Each jaw is armed with a band of teeth arranged in regular transverse rows (14 in the lower jaw), and so minute that, in the present specimen their number has been calculated to be about 6,000."

Kishinouye thus described the dental apparatus of his specimen:

"The teeth are very minute and numerous. They are nearly equal in size and shape. Each tooth is acutely pointed, laterally compressed, and with an ellipsoidal root. The band of teeth on the upper jaw is curved a little and at each end of the band there is a detached group of teeth. The band on the lower jaw is crescent shaped. In each band the teeth are arranged in a great many transverse rows, about 300 in number. In the middle part of the band we count 16-30 teeth in one row."

Bean says that the teeth of his Florida specimen are, "— in lower jaw in fourteen longitudinal rows; in upper jaw there are thirteen longitudinal and about three hundred vertical rows of developed teeth." His figure of the upper jaw of the Ormond

FIG. 131. TEETH OF ORMOND, FLORIDA, SPECIMEN (Enlarged).
After Bean (1905).

specimen is given herein as Figure 130, while Figure 131 is a magnified view of three of these teeth.

Last of all Lloyd found the teeth in his specimen to be small, numerous, recurved, in bands in each jaw. Each band had about 350 rows of teeth with about 10 teeth in each row, making approximately 7,000 in all.

Internal Organs.

This shark has been dissected by Smith (1849),[1] by Wright (1870), by Haly (1883) and recently by Van Kampen (1908). Unfortunately, however, none of these authors, save Smith, gives any account of the internal organs. Wright, who had more specimens at his command than any other naturalist, did practically nothing; and the same can be said of Haly and Van Kampen.

[1]Duméril's (1865) excellent account of the internal organs is mainly a translation of Smith's description.

Not so, however, Smith (1849) whose account will now be quoted verbatim.

"Pharynx very large and the inner extremity of each branchial canal obstructed by a sieve-like apparatus, consisting of a congeries of cartilaginous tubes closely set together, directed laterally, and the inner extremity of each fringed with a delicate membrane offering an obstruction to the passage of anything but fluid. Oesophagus rather narrow, and at its commencement bends downward toward the parietes of the abdomen, and forms nearly a right angle with the fauces, which gives the fish the power of completely preventing what enters its large mouth from being admitted into its stomach, unless desirable. The cardiac extremity of the stomach is very muscular, and the inner surface is studded with hard pointed nipple-like bodies, all of which are directed backward, and offer an obstacle to the return of anything solid from the stomach: the rest of the inner surface of the stomach and the small intestines closely set with strong rugæ, in the stomach oblique, in the intestines nearly circular; and the latter, when about to terminate in the large intestines is also furnished with a number of nipple-like bodies, which prevent solids from passing downward. The termination of the small intestine is in the form of a ring which projects into the large bowel and forms an effective valve when any attempt is made to propel the contents of the large intestine backwards into the smaller. The inner surface of the former is furnished as in other sharks with a spiral band, the one side of which is loose, and by this arrangement the alimentary fluid requires to pass over an extent of surface sufficient to permit of the necessary absorption of the nutritive portion of the ingesta. The rectum, internally, is quite smooth, and the gland which, in sharks generally, is situated behind it, also exists in this fish, and opens into the gut about six inches from the anus. On each side of the latter there is a large opening, through which a probe can be readily introduced into the cavity of the peritoneum, and into that cavity, it would appear, the sea water enters through these openings, as it contained about eight gallons perfectly pure, or at least only with some animal secretions.

"The liver consists of two lobes nearly of equal size, the length of each 3½ feet; the greatest width 13 inches, the least

6 inches. The gall-bladder is exterior to the surface of the liver, and is situated on its concave or dorsal aspect, close to its base, before it divides into lobes. It is of a piriforn shape, and the duct is much convoluted and so large as readily to admit the forefinger of a full-grown man; it discharges the bile into the upper extremity of the large intestines, and the point where it enters their outer coat is fully two inches higher than that at which it perforates the inner; the duct between these two points is contracted and tortuous, and the terminal opening is not larger than would admit a pea.

"The spleen is closely connected with the inferior extremity of the stomach and the hinder surface of the small intestine, and, excepting where it winds under the apex of the former, is lobulate, as in the true sharks, and exhibits a striking resemblance to the spleen of *Alopias vulpes,* Raf. The pancreas is slender, and partially encircles the upper extremity of the large intestine."

Food and Feeding.

When one sees or hears the word "shark," one instinctively thinks of a cold-blooded marauder of the seas, with a mouth filled with many rows of sharp, triangular teeth, with a voracious and almost insatiable appetite; a fish, in fact, not averse to human flesh, and with an active habit of life sufficient for the satisfying of such an appetite; in short, all the characters, real or imaginary, summed up in the great man-eater, *Carcharodon rondeletii.*

And yet here we are dealing with the veritable giant of sharks —the Whale Shark, *Rhineodon typus,* whose measured length runs from fourteen to forty-five feet, and whose length estimated by men accustomed to such reckonings may reach the vast figure of seventy feet, but whose manner of life is even more peaceful than that of the common dog-fish. For, be it known, that this largest among fishes is not merely a whale in size, but in manner of feeding, its almost microscopic teeth being in consonance with the minute size of the animals on which it feeds.

Smith, in his first paper, (1829), gives no intimation of the food of this great fish, but in his later (1849) and fuller paper he goes into the matter at length. Since he is the first and only

author to give a complete description of the alimentary organs he has been quoted in full in the preceding section. We will now see what he has to say as to the food of his shark and the manner in which it is obtained.

"The stomach was empty, hence the precise food of the fish could not be ascertained. That a portion of it, at least, is derived from the mollusca, &c., which are taken into the mouth and pharynx, with the sea water which is required for the purifying of the blood, is to be inferred from the branchial openings being so guarded. That the fringes at the inner extremity of the tubes, which exist in the branchial canals, are for the purpose of intercepting such small animals as may be contained in the water, I infer from knowing that the whale (Balæna), which feeds on small mollusca, &c., has the inner edge of each layer of whale bone converted into a fine floating fringe, which permits the water taken into its huge mouth to escape, but intercepts all objects adapted for its food.

"When our shark proceeds to feed, the first step it probably takes is to open its jaws to their full extent, in order to permit the mouth and pharynx to become filled with sea water. On that being accomplished, the jaws are then probably closed in order that the water shall, by muscular efforts in the pharynx, be propelled through the tubes in the branchiæ, and forced thus to leave behind it whatever mollusca, &c., it may chance to contain. The powers of deglutition after this are probably called into action, and the oesophagus, no doubt, is raised and straightened, so as to offer a ready passage downwards to whatever shall have been collected during the escape of the water. The mammillary eminences around the cardiac orifice of the stomach appear to indicate that some, at least, of the articles of food are swallowed alive, and that they require to be bruised and also prevented from re-entering the oesophagus, both of which are probably effected by the processes just mentioned. The direction taken by the upper part of the oesophagus is evidently for the purpose of enabling it the more effectively to resist the entrance of the water, when being expelled through the branchiæ by the muscular contraction of the pharynx."

The man of all others who has had the greatest opportunity to study the feeding and other habits, and who was guilty of

the greatest error, was E. Perceval Wright. While at the Seychelles, just prior to 1870, he dissected at least two specimens, male and female, and wrote that he was able "to preserve all the more important parts of each for more careful examination in Dublin." That he ever did so, however, I have been unable to ascertain. As to its food, here is what he says (1870): "——contrary to the general habits of the true sharks, it is not a carnivorous but a herbivorous fish." However, Steenstrup (1873),[1] having conclusively proved that the great Basking Shark, *Selache* (*Cetorhinus*) *maximus*, which had been thought to feed on algæ, is by virtue of its curious gill apparatus a feeder on small marine organisms, severely criticized Wright's theory of herbivorous feeding in *Rhineodon*. Wright, having satisfied himself by study of *Selache*, that this animal is a carnivore, in 1876 acknowledged his error in these words: "——I now have no doubt that both these big lubberly beasts—which in their mouths have scarcely more than the name of teeth—feed on all sorts of minute oceanic creatures, frequently taking in with them floating algæ.'

Again in 1877, Wright says, and repeats the statement in his *Animal Life* (1879):

"I found large masses of algæ in their stomach, so that at one time I was inclined to think it was an herbivorous shark, probably, however, it derives its nourishment, in part, at least, from minute crustaceans and other oceanic animal forms, which may be taken in along with masses of floating weed, and, then ejecting the water through the strange mesh-like structures that unite the edges of the great gill openings, obtain by so doing enough to swallow."

Günther (1880) writes: "——It has been stated to feed on tang, an observation which requires confirmation." Who the author of this observation is, I have been unable to ascertain. In 1884 Günther, seemingly in ignorance of Steenstrup's and Wright's discussion, cast strong doubt on the herbivorous feeding of the Seychelles fish. Haly (1883) merely notes that "the stomach contained a quantity of finely divided red matter." This was probably crustacean remains. While Gill (1905) clearly

[1]Both Gill (1902) and Bean (1905) erroneously attribute this reference to Lutken.

shows that its food consists of the plankton strained out of the water by its peculiar gill apparatus.

In the stomach of Kishinouye's Japanese specimen (1901), there was found a sucking fish and a fragment of an oak pole one foot in length. A number of sucking-fish were found adhering to the shark when it was caught. Chierchia reports that several were adhering to the inside of the mouth of his specimen.

Van Kampen dissected a fair-sized specimen at Batavia, Java, and reports as follows: "In its stomach I found nothing save some sepia shells, and some small fish (*Gobies, Sauries*)."

Habits.

Offensive Habits.

The Whale Shark, which is in size the chiefest of the Selachians, has absolutely no offensive habits. Its huge bulk may inspire terror, but it is the quietest and most inoffensive of marine animals. The nearest approach to offensive habits is indicated by Wright, who says that: "——it now and then rubs itself against a large pirogue as a consequence upsetting it, but, under such circumstances, it never attacks or molests the men, and while it reigns as a monster among sharks, is not, spite its size, as formidable as the common dog-fish." This action, it may be conjectured, arises either from playfulness or from a desire to rid itself of barnacles or other marine growths.

Defensive Habits.

In such habits, *Rhineodon* seems likewise to be entirely lacking. Smith, its discoverer, says that: "When approached it manifested no great degree of fear, and it was not before a harpoon was lodged in its body that it altered its course and quickened its pace." Dr. Buist says that when harpooned at Kurrachee it is allowed to tire itself out, is pulled in, stunned with clubs and then dragged into shoal water. Chierchia's specimen when struck ran first in circles and then straight away for three hours at a velocity of more than two miles per hour, trying to escape but offering no violence whatever.

Mr. Brooks, in his letter quoted above, notes that the second Florida specimen, at whose capture he was present, did not seem

to be frightened at the approach of the boats, made no resistance when harpooned, when shot, or when pulled to the surface, swam continually in circles, and despite everything done to kill it "seemed to fail to recognize that anything in particular was happening to him."

Beyond seeking to escape by slowly swimming away, this gigantic elasmobranch rarely makes any defense. The only naturalist who tells us anything to the contrary is Wright. He says (1876): "Men engaged at the sperm-whale fishery off St. Denis often told me they dreaded to harpoon by mistake a *Rhinodon.* A whale must come up to breathe or else choke itself. But there were stories told me of how a harpooned *Rhinodon,* having by a lightning-like dive, exhausted the supply of rope which had been accidentally fastened to the boat, dived deeper still, and so pulled the pirogue and crew to the bottom—where, in spite of the harpoon in its neck and its attendant encumbrances, it was at home for a great length of time." And Dr. H. M. Smith (1909), in his interesting paper "Some Giant Fish of the Seas," has a spirited picture showing the fish making the dive.

However, Dr. Gill (1902) seems to doubt this report, which it will be noted is hearsay evidence only, and to the present writer, after a careful study of all the known literature of *Rhineodon,* it seems that Wright has probably been misled. Even when taken in nets (Haly, Kishinouye) there is no evidence that it makes any serious defence. Undoubtedly, *Rhineodon typus* is the mildest mannered shark that swims the seas.

Breeding Habits.

Of such habits there is unfortunately no record of any observation whatsoever. Smith's specimen (so we are informed by Müller and Henle) was a male, but in neither of his papers (1829 and 1849) does he refer to its reproductive organs. Wright and Haly have both dissected females, and the latter expressly says that he was (vainly) hoping to find eggs or embryos, but neither gives any information whatsoever about the organs of generation. The second Florida specimen seems to have been a male, but unfortunately it was not dissected by any scientific person. Probably the Whale Shark is viviparous.

Mounted Specimens.

So far as can be found, the preserved specimens of *Rhineodon typus* in the museums of the world are as follows: (1), Smith's original specimen, preserved by J. Verreaux and now in the Museum of Paris; (2), the one mounted in 1883 in the Colombo Museum under the direction of A. Haly; (3), the one in the British Museum (Haly's second specimen) mounted by Gerrard about 1890; (4), the Madras specimen of 1889, presumably mounted under the direction of Thurston; (5), the Japanese specimen (1901) preserved by a local curio dealer in Tokyo; (6), the first Florida specimen (1902), the skin of which is preserved in the United States National Museum; (7), Capt. Thompson's specimen from Florida, now on exhibition in the various cities of the United States.

Name.

At first (1829) Smith gave his great shark the name *Rhincodon typus,* but later (1849) changed it to the more common forms *Rhinodon typicus.* The reason for this will now be given.

In 1831 Bonaparte followed Smith in using the generic name *Rhincodon.* In 1838-1839 Swainson published the names *Rineodon, Rhineodon* and *Rhiniodon.* About the same time Müller and Henle, at the conclusion of their visit to London made to collect data for their great forthcoming work on Selachians, published in the *Magazine of Natural History* and in *Archiv für Naturgeschichte* (1838) a preliminary paper in which they give the genus *Rhineodon,* but three years later (1841), when they published their great work on sharks and rays entitled *Systematische Beschreibung der Plagiostomen,* they gave this shark the name *Rhinodon typicus,* which has been the one commonly used ever since. Careful scrutiny of their work reveals no reason whatever for this change. However, when Smith (1849) came to give his larger and more complete description of the Whale Shark, he gave up the name he had first used and adopted the last one propounded by Müller and Henle.

Dr. Gill in 1902 used the name *Rhinodon typicus,* but noted that *Rhineodon* was the first generic title. In his second paper, however, this great ichthyologist returns to the correct name

Rhineodon typus, which in accordance with the rules of priority must be used. But why not *Rhincodon,* may be asked. It is true that the printer in England mistook Smith's "e" for a "c," and Smith being at the Cape of Good Hope, this error was uncorrected. But since the derivation is *rhine,* file + *odous* (odont) tooth, it would be absurd to let the error stand, and hence the present writer has used what seems to him the correct terminology, *Rhineodon typus.*

Since the above went to press I have found the following statement by Günther (1910): "The name in this publication [*Zool. Jour.* XVI. 1829] is *Rhincodon;* this appears, however, to have been a typographical error, at least the original drawing, which is in my possession, is labelled in Smith's own hand *Rhinodon typicus.*" This, however, does not negative the above conclusions, since this finished drawing, first published in 1849, was presumably not made until some time, possibly long time, after 1829, and in the name Smith simply followed Müller and Henle (1841).

NOTE:—Dr. David Starr Jordan, in *Science* for March 26, 1915 (page 463), records the receipt from Mr. W. F. Cameron, a correspondent of his at Zamboanga, Philippine Islands, of a photograph of a 20-foot specimen of the Whale Shark, taken at the Island of Zebu. In its stomach were found a number of shoes, leggings, leather belts, etc., a most incongruous mass of stuff in reference to what we know of the feeding habits of this great shark. This adds another to our short list of specimens, and the second for the Philippines. E. W. G.

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OF
ECTOPARASITIC TREMATODES

By G. A. MacCallum, M.D.
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COLUMBIA UNIVERSITY, NEW YORK.

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SOME NEW SPECIES
OF
ECTOPARASITIC TREMATODES

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Fig. 133. *Diplectanum lactophrys.*

Fig. 134. Comparative view of cirri of several species of *Diplectana*:—

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Fig. 135. *Diplectanum balistes.*

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Fig. 137. *Atalostrophion sardae.*

Fig. 138. The entire intestinal tract of young *A. sardae.*

ABBREVIATIONS

See Plates

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b. ej.—bulbus ejaculatorius
c.—cirrus
d.—disc
d. e.—ductus ejaculatorius
ex. d.—excretory duct
ex. p.—excretory pore
es.—esophagus
g. a.—genital atrium
g. p.—genital pore
i.—intestine
m.—mouth
m. b.—muscular bands
oot.—ootype
o. s.—oral sucker
ov.—ovary
ovd.—oviduct
ph.—pharynx
p. p.—pars. prostatica
pr.—prostate
p. s.—penis shell
s. g.—shell gland
s. p.—sensory papillae
s. r.—seminal reservoir
t.—testis
u. g.—unicellular glands
ut.—uterus
va.—vagina
v. d.—vas deferens
v. s.—vesicula seminalis
vit.—vitellaria
v. r.—vitelline reservoir

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Introduction.

The Director of the New York Aquarium has been good enough during the past two or three years to place at my disposal numerous exotic and other fishes which have died there. I greatly appreciate the privilege, for it gives me the opportunity to secure biological specimens which I could not obtain otherwise.*

Among these there have been found many forms of parasites of new species and even genera, which it has been thought should be published, and, with that object in view, in the following paper five new species and one new genus are submitted. The form from *Sarda sarda, Atalostrophion* is a particularly interesting trematode.

When one considers that these worms are always parasitic and that in many instances the death of their host depends upon the numbers which cause the infestation, it becomes interesting to know how they are propagated. This fact also makes the study of their anatomy more interesting since almost all of them are hermaphroditic. They are supplied with two complete sets of generative organs and when these are thoroughly described there is but little left to say about the worm's anatomy, since they form the main portion of its body. Although their habits

*Dr. MacCallum has kindly autopsied and reported upon the cause of death of large numbers of fishes from the Aquarium during the past few years, only a few of which are mentioned in this paper. The importance of such studies in fisheries work is very great, and an aquarium offers special advantages for this work on account of the greater opportunity for infection and the protection afforded diseased fishes, which, in natural conditions, would be quickly destroyed by their enemies. This paper is properly a contribution from the Biological Laboratory of the New York Aquarium.—*C. H. T., Director of the Aquarium.*

are interesting, where they may be studied, it is not often that an opportunity is afforded to see them alive and pursuing their usual mode of life. This, however, is quite possible in some cases, for instance, where Microcotyle infest the gills of certain fish. By exposing the gills they may be seen literally covered with the worms hanging on the gill filaments while they suck the blood from under the delicate mucous membrane. On the gills, too, may be seen the eggs deposited in hundreds and held in position by the tangled filaments which are attached to either end of the egg. As soon as they are hatched they are prepared to fasten themselves on the gills and to take up the reproduction of their kind and to continue the work of their ancestors. The great irritation caused by all this action induces an outflow of thick mucus, covering the gills and preventing the access of the water to their surfaces, so that the fish even may be suffocated. In addition to this they cause great depletion of blood which soon renders the fish exsanguine and causes its death.

Another strange habit with most of these parasitic worms is, that they have a particular locality or habitat where they confine themselves in or on the body. Thus the *Microcotylidae, Diplectana* and *Octocotylidae* are found no where else than on the gills, and the former worm is at least the cause of death of ninety per cent of the angel and butterfly fishes in the tanks of the Aquarium. They are probably not so plentiful, and consequently not so fatal to these fish in their natural habitat, the open sea.

DIPLECTANUM

SUB-FAMILY GYRODACTYLIDAE

Genus *TETRAONCHUS*

Sub-genus *Diplectanum*

Among the ectoparasitic trematodes there are few which while being as small, are yet more interesting than these forms.

They have been classed in the order *Heterocotylea* and included by Van Beneden and Hesse in the family of *Gyrodactylidae.* As far as known now, they are confined to the gills of marine fishes and we have no record of them until 1857, when Wagener was fortunate enough to discover three members of the

family. These he named *Diplectanum aequans,* found on the gills of *Labrax lupus; Diplectanum pedatum* on the gills of an unknown fish of the Julis family, and *Diplectanum echeneis* on the gills of *Sargus rondeletii.* However, other than naming them he gave little or no description of the worms by which they might be recognized.

In 1862 Van Beneden and Hesse did the genus more justice, but it was not until 1904 that it was much more completely described by MacLaren, who has endeavored thus to make *D. aequans* the type species.

In 1862 Van Beneden and Hesse described the worm discovered by them as *D. sciaena* from the gills of *Sciaena aquilla,* one of the drumfish.

Parona and Perugia discovered and described a form which they called *D. aculeatum.* We have then thus far five members of this sub-genus described as follows:

> *Diplectanum aequans,* Wagener, 1857, Diesing, 1858, MacLaren, 1903; *Diplectanum pedatum* Wagener 1857; *Diplectanum echeneis,* Wagener, 1857; *Diplectanum sciaena,* Beneden and Hesse, 1863 and 1864; *Diplectanum aculeatum,* Parona and Perugia, 1890.

In 1904, when Norman MacLaren wrote very fully upon *D. aequans,* he also summed upon what had been written of the other forms to that date.

Diplectanum teuthis, nov. sp.*

(Fig. 132)

On May 22, 1914, I found *Diplectanum teuthis* on the gills of a *Teuthis hepatus,* a small worm of this species which differs in many particulars from any of those hitherto described, consequently I have ventured to name it *D. teuthis* and to call it a new species. It is only .75 mm. in length by .10 mm. in width. However, its anatomy is fairly distinct so that a reliable description may be given of it.

*All of the forms described in this paper were found in material from the New York Aquarium.

The body of the worm is elongated, slender and ends posteriorly in a trumpet-shaped disc, which is armed with four strong yellow chitinous hooks of a peculiar shape. There are also in this locality a number of stiff hair-like processes which extend some distance anteriorly from the disc along the posterior end of the body. I wish to draw attention to the shape of these hooks, which are shown in Fig. 134. The hooks in the disc have as their foundation of attachment, two blocks of chitinous material. These are placed, one anteriorly and the other posteriorly in the wall of the hollow disc. They act with a certain amount of motion as if jointed, and thus allow free action of the hooks, which are under the control of the worm.

The head is narrow and unarmed with a notch at the anterior end which marks the situation of the mouth, and on each side of this there are three tactile papillae which stain more highly than the surrounding structure. These areas seem also to furnish some secretion, since small ducts may be seen proceeding backward from them as far as the pharynx. Their function is, as in all of these worms, to afford mucus or saliva to the pharynx and esophagus and to enable them to feel their way about. Anterior to the pharynx are four ocular spots. The pharynx is large relatively and is succeeded by a very short posterior pharyngeal esophagus, since it divides almost at once into the intestinal ceca. On each side of the pharynx and beginning of the intestinal ceca are a number of unicellular glands. A short distance posterior to this angle but also in the center of the body is the genital pore surmounted by a very prominent organ, the chitinous cirrus, which in this species is of the shape of a sickle with the handle.

The *male genital* apparatus consists of a single testis, oval in shape and relatively large. It is situated posterior to the ovary and the vas deferens passes dorsally over the ovary on its way to the large ductus ejaculatorius; this duct gives off a tube which proceeds somewhat backward to enter the bulbus ejaculatorius, being surrounded just before entering that organ by the prostatic gland. The bulbus ejaculatorius is a more or less round organ or muscular bag through which the vas deferens passes to the base of the cirrus. The cirrus is peculiar. Its shape being that of a sickle, including the handle, which latter

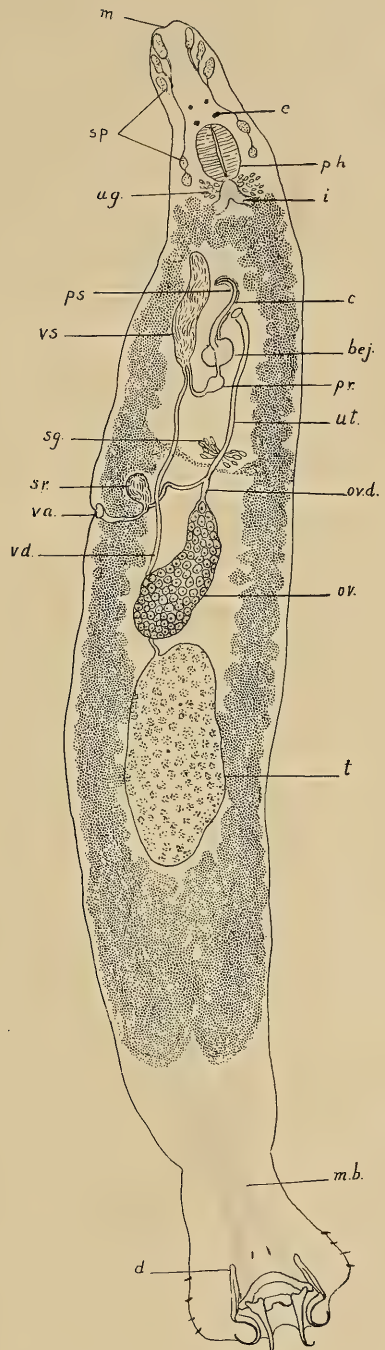

FIG. 132. *DIPLECTANUM TEUTHIS*

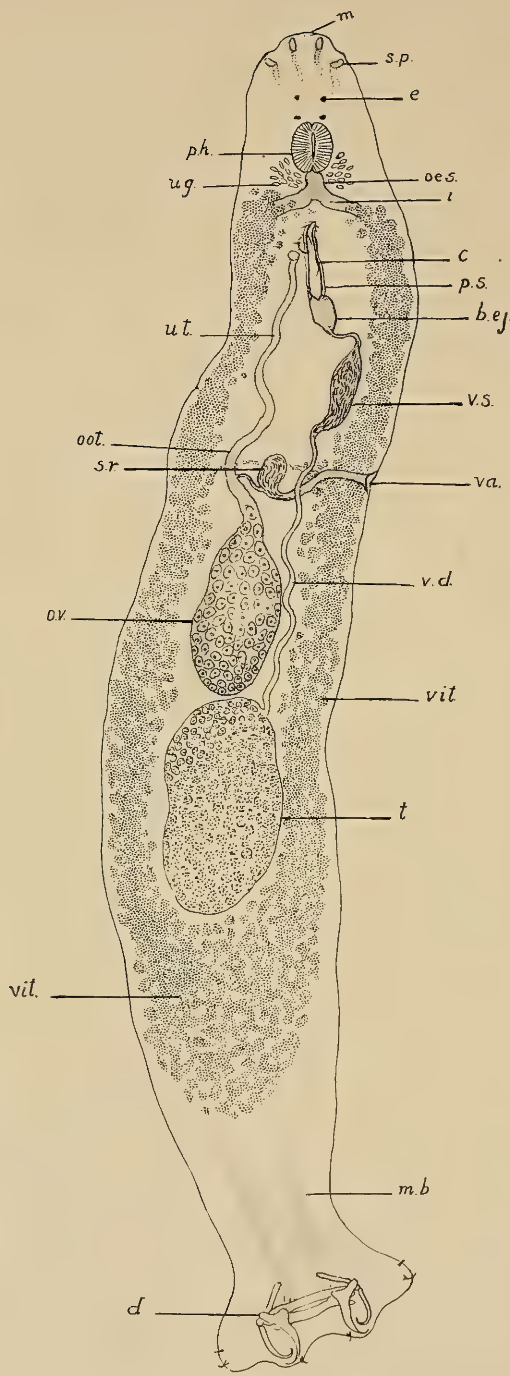

FIG. 133. *DIPLECTANUM LACTOPHRYS*

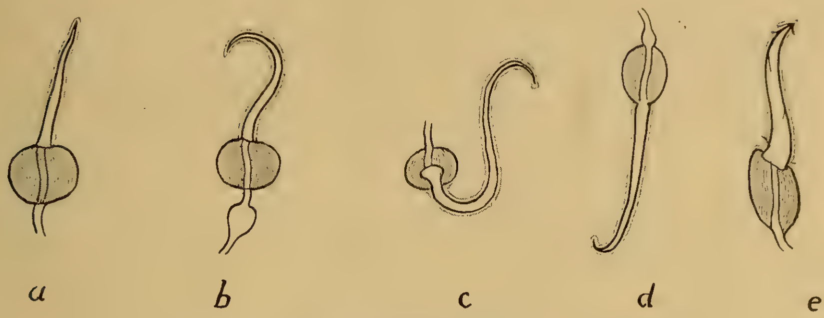

FIG. 134. CIRRI OF SEVERAL SPECIES OF *DIPLECTANA*

seems to form part of the ejaculatory apparatus. The organ itself is a hollow tube, much bent and composed of yellow chitinous material (Fig. 134b).

The *female genital* apparatus consists of a reniform ovary situated about the middle of the body. The oviduct is short and the genital junction is a short distance anterior to the ovary. On the right side of the worm may be seen the opening of a vagina which joins the seminal reservoir near the genital junction.

The vitellaria are plentiful and extend on each side of the body near the pharynx to a short distance anterior to the disc; small vitelline ducts are sent almost horizontally to the genital junction from each side.

The uterus extends from the ootype near the genital junction to an atrium near the base of and to one side of the cirrus.

Measurements of *Diplectanum teuthis*:

Length	.75 mm.
Width	.10 mm.
Length of cirrus	.04 mm.
Diameter of disc	.08 mm.

Diplectanum lactophrys, nov. sp.

(Fig. 133)

On February 19, 1915, there were found on the gills of a cow fish, (*Lactophrys tricornis*), a colony of small *Diplectana*

which owing to a few characteristics not possessed by other members of this family, must necessarily make it constitute a new species. It is small, being only 1 mm. in length by .10 mm. in width; it has, however, the usual general conformation of the genus.

Its body is elongated and narrow and of almost an equal width throughout, except at the posterior end where the hook disc is somewhat wider. The disc is, however, quite different from any of the forms hitherto described; it is more footlike in shape,—in fact, in some specimens it is quite the shape of a foot, but ordinarily it extends equally on each side of the end of the body. This shape is caused largely by there being on each side a prolongation of skin, which is armed with two small hooks. Then on each side of the notch in the centre of the distal margin there is fixed another small hook. In the centre of the disc towards its margin are two small blocks of yellow chitinous tissue, which give attachment to the bases of the main hooks of the disc, of which there are, as usual, four—two attached to the block placed in the anterior wall of the disc and two attached to the posterior block.

These blocks are of a peculiar shape and differ in each species (Fig. 133). The blocks are each separated into parts which like joints allow of the motion of the hooks at the will of the worm. As will be seen also if observed closely, the hooks are not of the same shape as those of other members of the genus. In the posterior region may be seen the muscular bands which extend from the disc up into the body and which control the movements of the disc with its hooks. Some bands, if not the chief ones, are seen to pass from one side of the disc to the opposite side of the body. This is probably for the more varied adjustment of the hook disc.

The head in its general conformation and the organs of the body generally are much the same as in the description given of the type except in the cases of the cirrus which is quite different and will constitute one decided point in the diagnosis of the species.

The *male genitalia* are the single large roundish testicle, which lies posterior to the ovary in the center of the body. It gives off from its anterior part the vas deferens which runs

along the left side of the abdomen to empty into a rather large irregularly shaped vesicular seminalis situated opposite the base of the cirrus. This reservoir furnishes a small tube which enters the bulbus ejaculatorius and passes to the pointed base of the cirrus which points to and sometimes overlies the genital pore. The cirrus here is long and straight except near the tip where it becomes curved and pointed. At its base it is provided with an oval bulbus ejaculatorius quite elongated while in nearly all of the other species this is round or nearly so. The base, too, of the cirrus is pointed where the tube or vas deferens joins it; it then shortly widens until it suddenly narrows to the portion outside of the bulbus ejaculatorius. The cirrus proper, however, is of firm chitinous tissue which cannot alter in shape even during conjugation, so that as it is quite prominent it shows a good index of the species (Fig 134e). The cirrus is enclosed in a sort of shell or outer cover and in this instance the penis seems to be armed near the tip with fine spicules, and there appear a few of these spicules also near the base. It is barely possible that this condition may be owing to faulty refraction, still as almost all of the specimens show the same it probably is true.

The *female genitalia,* as usual, consist of an ovary, oval in shape, becoming pointed anteriorly and from which part arises the oviduct—this is not long before it receives the duct from the seminal reservoir and the vitelline ducts; the ootype follows and merges into the uterus, being surrounded here by the shell gland. The uterus terminates with a somewhat flaring mouth at the genital atrium. The vagina opens at the left side of the body when it is looked at from the ventral side of the body. The *vitellaria* are plentiful, extending on both sides of the body from near the pharynx to near the posterior end and across the body posterior to the testis.

These worms are all ectoparasitic, living on the gills of marine fishes. They are not as a rule found in great numbers, although there may be many more than appears since they cannot be seen in situ on the gills, and they do not wash off readily on account of the firm hold of the hooks. The fish as a rule which are infested with them become thin and flabby, and finally die, probably owing largely to the ravages of the worm when in great numbers.

Measurements of *Diplectanum lactophrys*, n. sp.

Length of body	1 mm.
Width of body	.10 mm.
Diameter of disc	.15 mm.
Length of cirrus	.10 mm.

Diplectanum balistes, nov. sp.

(Fig. 135)

On January 13, 1913, on the gills of a trigger fish, (*Balistes carolinensis*) were found a few examples of a small worm which on close study proved to be a *Diplectanum* and a new species, inasmuch as it differs from any others of the genus examined. It is but .55 mm. in length by .09 mm. in width. The body is elongated and, unlike many of the other members of the family, it becomes decidedly and abruptly smaller near the discal end and the disc itself is very different from that of the others. Instead of being trumpet-shaped it is merely a straight tube armed with four hooks and about six smaller ones. The large ones measure .02 mm. and the smaller ones .003 mm. The hooks also are different in shape from those of the other forms described (Fig. 135).

The *male genitalia* consist of one testis situated near the middle of the body and just posterior to the ovary. The vas deferens runs dorsal to the ovary in a convoluted form to join a fusiform vesicula seminalis which lies to the left of and slightly posterior to the genital pore. At its anterior end it narrows into a small tube which enters the bulbus ejaculatorius and passes through to enter the cirrus, which in this instance is an almost perfectly straight tube (Fig. 134a) and in the specimen under observation lies pointing anteriorly directly across the genital pore. It is almost .04 mm. in length.

The *female genitalia* consist of the ovary lying, when viewed ventrally, partly on the testis. It is oval and narrows anteriorly into the oviduct, which is almost immediately joined by the duct from the seminal reservoir which receives the vagina from the right side. The genital junction is just anterior to the ovary and the uterus, which is short, terminates at the edge of the genital pore.

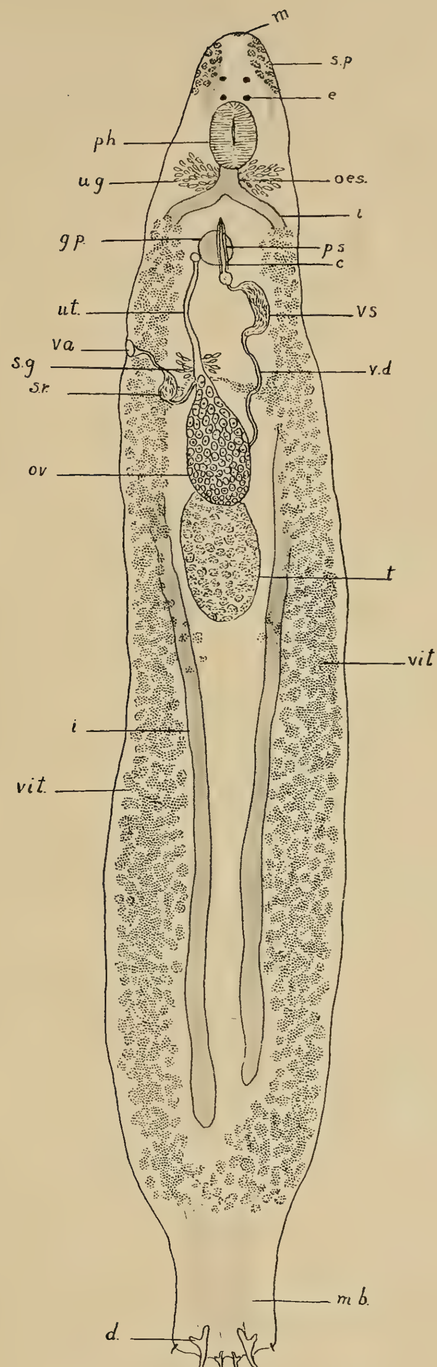

FIG. 135. *DIPLECTANUM BALISTES*

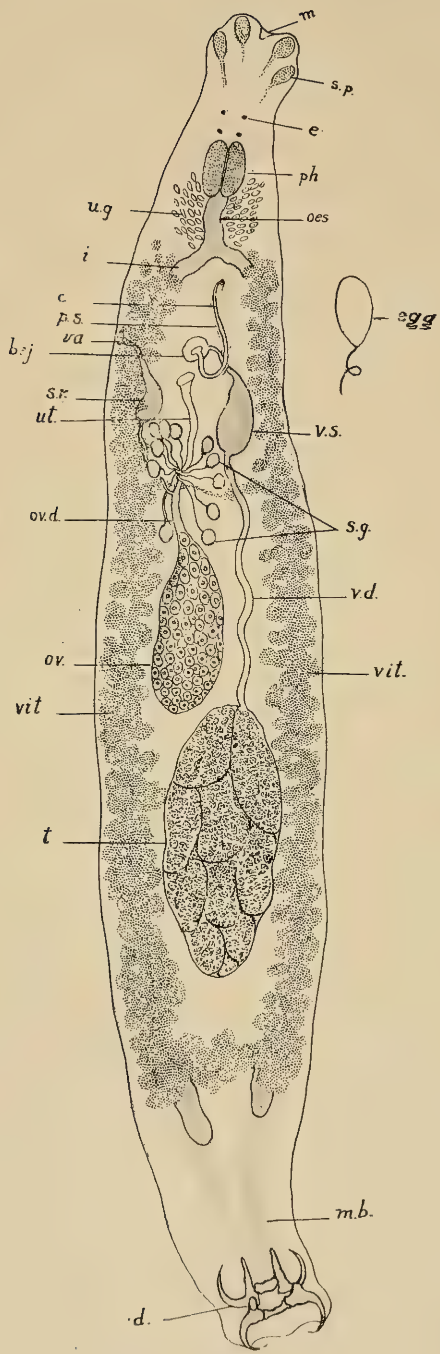

FIG. 136. *DIPLECTANUM LONGIPHALLUS*

The head is formed much like that of others of the family, a slight notch at the extreme tip and on each side a row of papillae extending back almost to the pharynx, which is large. The post-pharyngeal esophagus is short and the angle on each side of the pharynx and esophagus is filled with unicellular mucous glands. Anterior to the pharynx are the usual four ocular spots. The vitellaria are plentiful and extend almost from opposite the genital pore to the point posteriorly where the body suddenly narrows to form the disc. The hooks on the disc have their bases attached to the usual two chitinous blocks of yellow material. These are not of the same shape as in *D. teuthis* or *D. longiphallus.*

For the purpose of description, the characteristics of the worm are, that it is small, has a straight tubular disc end, four large hooks and several small ones clustered in the end of the disc, and the cirrus straight and pointed.

On account of these peculiarities the worm must be considered a new species and the name *D. balistes* is proposed.

Measurements of *Diplectanum balistes.*

Length	.55 mm.
Width	.09 mm.
Diameter of disc	.035 mm.
Width of head	.02 mm.
Length of cirrus	.04 mm.

Diplectanum longiphallus, nov. sp.

(Fig. 136)

On January 23, 1915, there were found on the gills of a spade fish, *Chaetodipterus faber,* a colony of *Diplectana,* which apparently are different from those described heretofore.

In general appearance they are like those found on the surgeon fish, (*Teuthis hepatus*) and in *Balistes Carolinensis,* or trigger fish, but in detail the anatomy is somewhat different. Like them it is small; being only about 1 mm. long by .15 mm. wide. The clinging disc seems in general form the same in almost all, a firm terminal mass with four relatively large, strong hooks attached to odd shaped chitinous blocks, which serve to support the

hooks and increase the firmness of their grasp on the tissues to which they cling. The head is similar, with the usual tactile or sensory papillae on each side, in this instance only two but somewhat larger than in the other forms. An esophagus can be made out between the pharynx and the mouth end and in front of the pharynx are the usual four ocular spots. The pharynx is large and the post-pharyngeal esophagus is longer before the division into ceca than the pre-pharyngeal portion. The genital pore is in the angle between the ceca in the centre of the body and this is surmounted by an oddly shaped chitinous cirrus, quite different from those of the forms above mentioned (Fig. 134c). In this instance it is very long and much bent or curved.

The *male genitalia* are very similar to that usual in the species but with some peculiarities. For instance the testis is single, very large and enclosed in a membranous sac, is divided into large lobes, and is more or less pointed anteriorly. It is situated posteriorly to the ovary and from the anterior end gives off the vas deferens, which passes forward to empty into a large seminal vesicle, placed alongside of the genital aperture on the left side; from this the vas passes into the bulbus ejaculatorius before terminating in the cirrus.

The *female genitalia* consist as usual of the ovary, which is large, oval and pointed anteriorly where it gives off the oviduct. The vagina is not very definite in most of the specimens before me but in most of them the situation of the seminal reservoir is seen and a tube leading to the oviduct is evident. The shell gland in this species is peculiar since it is composed of ten or fifteen large, round, cellular masses that communicate with the ootype by means of long tubes, and give the glands the appearance of being set up on stalks. The vitellaria are very plentiful and the vitelline ducts meet and join the oviduct anterior to the entrance of the duct from the seminal reservoir.

The uterus is not long and terminates with a somewhat flaring mouth near the genital pore near the bulbous end of the cirrus. Several eggs are seen in the eight or nine mounted specimens before me; one in each. These are yellow, oval and with a filament at the posterior pole,—length .02 mm. (Fig. 136.)

For the purpose of classification this form shows the following special characteristics: Shell gland unusually prominent

and composed of ten or fifteen large round glands with very long ducts. Cirrus quite long, a good deal curved and with an oval bulbus ejaculatorius which appears quite muscular. Testis lobulated. These differences from the other species described force me to regard this as a new species for which the name of *Diplectanum longiphallus* is proposed.

Measurements of *Diplectanum longiphallus.*

Length	.95 mm.
Width	.15 mm.
Length of cirrus	.25 mm.
Length of disc	.08 mm.
Width of head	.05 mm.
Egg	.02 mm.

Atalostrophion sardae, nov. gen. & nov. sp.

(Figs. 137 and 138)

During the summer of 1912, I first found on the gills of the bonito, (*Sarda sarda*) by washing, a number of fragments of a small, flat, ribbonlike worm. It was always found to be broken at the end, but when stained and mounted it was seen to contain internal organs of a tubular form; that is, there were two, sometimes three tubes containing eggs, which were portions of the uterus. Between these uterine tubes was a brownish tube containing brownish yellow granules—the vitellarium—and besides these could also be seen the tubular testis and a vas deferens containing spermatozoa. No matter how many pieces were examined from the gills, they were always imperfect; both ends being torn across. This was the case during 1912 and 1913, although very few bonitos came to autopsy in the laboratory. However, it was determined in 1914, that an attempt should be made to find out the origin of the pieces and to secure a whole worm if possible. As a result of this determination sixteen bonitos were examined in all and seven of them found to be infested with the worm. It was then discovered that the worm had its habitat not in the gills of the fish, but was found in great numbers under the mucous membrane of the branchial cavity on each side of the isthmus, and also was

found embedded in great numbers in the thyroid glands and throughout the substance of the isthmus itself.

When the muscular layers were carefully parted, the worm was seen flattened in tangled layers. Some of these were seen dangling from the surface in loops, the examinations being made under water, as this was the simplest way to secure a view of the parasites in situ. I have no doubt now that the loops are broken off by the action of the gills and water and become entangled in the meshes of the gills, doubtless for the purpose of distribution in one way, since every fragment is loaded with eggs. It is certain, however, that the local habitat of the worm is in the cellular tissue under the skin and mucous membranes of the branchial cavity and neighboring tissues of the throat, including the space between the muscular fasciculi of the muscular tissues of the isthmus.

It may be said, that a great deal of time has been spent with most careful and assiduous research in the endeavor to find a whole worm. Out of the hundreds traced and teased out only two whole worms have been secured and both of these were immature. Three or four ends, however, have been secured,—heads and tails of adults which are shown in Figs. 137 and 138. It has been concluded that it is next to impossible to tease out an adult worm from the fact that they all seem to be imperfect. One may lift carefully the mucous membrane or a layer of muscular tissue from a tangled mass which certainly has never been disturbed or injured before, and examine the specimens as carefully as possible in situ, and it is almost impossible to see a perfect end; let alone a whole worm. In consequence one must conclude that it is natural for the worm to disseminate its eggs by throwing off the parted sections, as well as by the natural exit from the uterus. The one young specimen secured is 50 mm.—nearly two inches long—and the other more developed one is about 70 mm. in length. Even though dissecting with the greatest care and using a stereoscopic lens, on no occasion have I been able to secure a piece of the body of greater length than 75 mm. This is not to be wondered at when it is known that the worm is only about .60 of a mm. wide; not more than as thick as tissue paper. Its structure, too, seems to be very delicate; breaking at the slightest touch, almost. The skin is smooth and unarmed. It is difficult to state the length of an

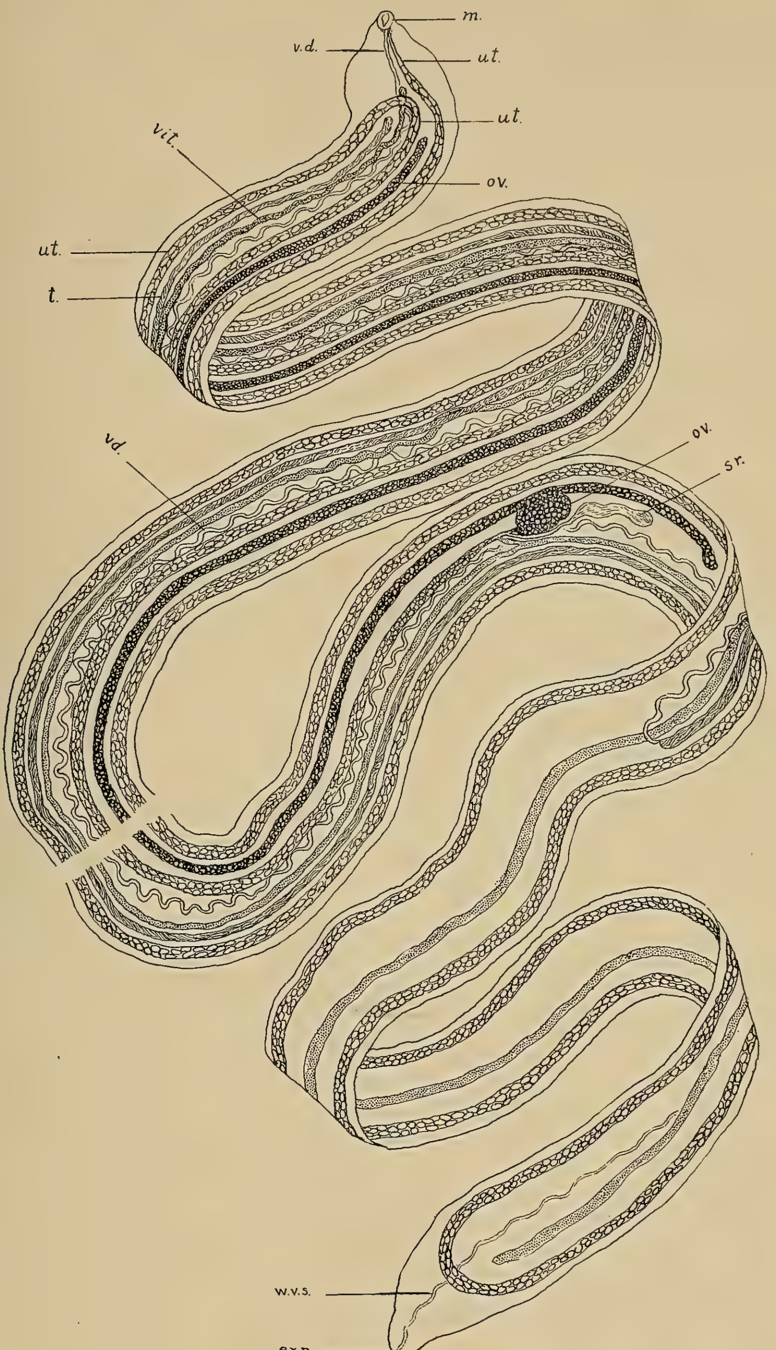

FIG. 137. *ATALOSTROPHION SARDAE*

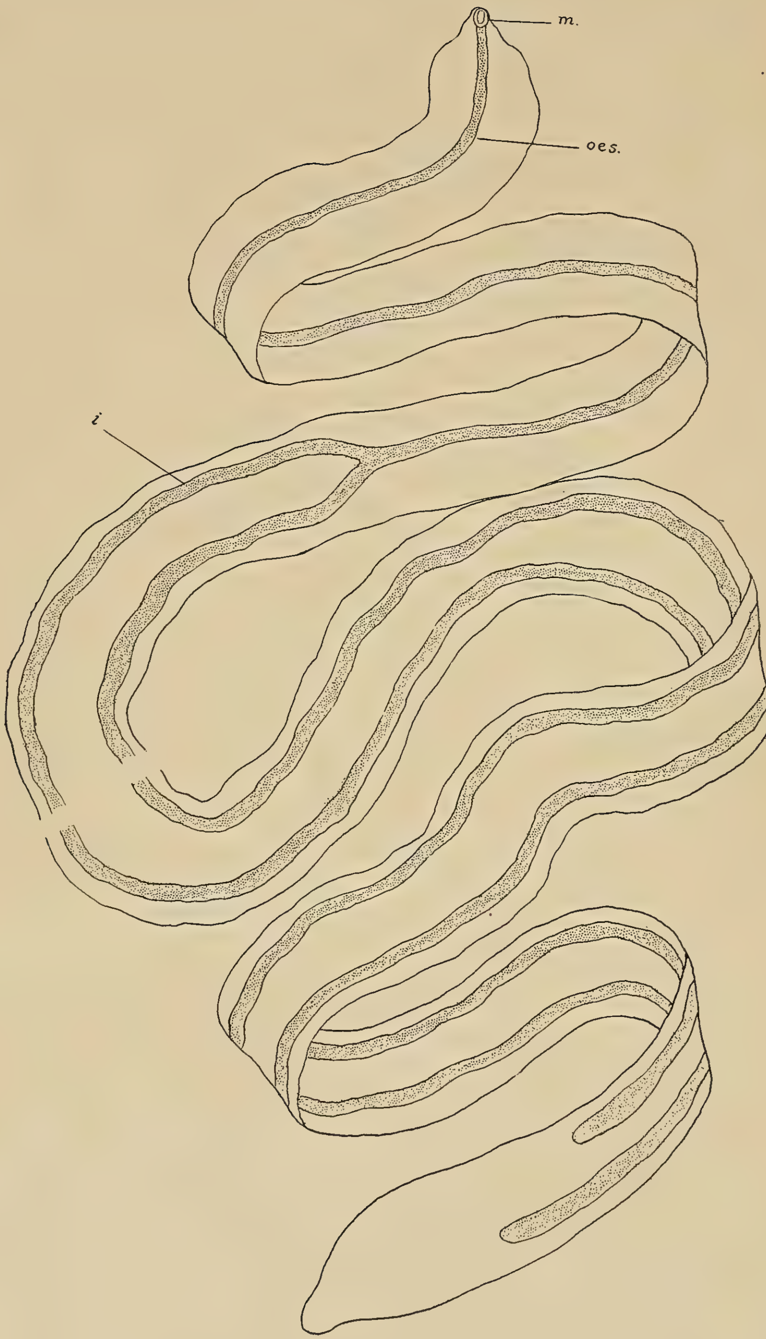

FIG. 138. INTESTINAL TRACT OF *A. SARDAE*

adult worm. I have pieces three inches long and from my experience in trying to get a whole worm by putting the pieces together, I would say that I believe five or six inches the maximum length. In the figures the worm is shown cut across, because a whole adult worm has not yet been dissected out to make a certainty about length.

The worm sometimes seems to have all the organs, and the uterus full of eggs, etc.; the form of body will then abruptly change to a much narrower and thinner shape and to a milky white color, with only a water vascular canal in the middle, running through the middle the entire remaining length, perhaps for an inch or so, and coming to a fine point or be broken off when not larger in diameter than a hair.

In one of the young worms the esophagus and intestinal ceca are plainly shown and are depicted in Fig. 138. As may be seen in the figure, the esophagus extends from the mouth about one-third of the length of the worm, when it divides into two ceca which extend nearly to the posterior end of the worm. No pharynx is seen.

The mouth is an oval opening distinctly marked out. It is slightly sub-terminal and may be observed when the worm is on its back. The anterior ends of the uterus and vas deferens plainly pass under the posterior edge or lip, and disappear in the mouth, which must therefore be the outlet for their contents. Eggs are seen in utero, a very short distance from the end, but no mouth of the uterus can be seen. The tissues of the body in this locality, as well as elsewhere outside of the organ, appear to be a fine network of muscular fibers with small cells and fine granular matter sparingly distributed. In some of the specimens the head which is very small appears to be connected with the body by a decided neck, but of course this varies as the result of muscular action. No nervous system can be made out, but a water vascular system is present and the small vessels gradually coalesce towards the tail until the main vessel often can be seen making a zig zag course to the outlet.

The *female genitalia*, as far as can be made out, consist of the ovary which is a thick somewhat curled tube extending from near the anterior end to about the junction of the posterior with the anterior two-thirds of the worm. It stains deep red with carmine. In some specimens there is an enlargement a

short distance from its posterior end in which the ova seem riper than elsewhere. Just behind this portion of the ovary may be seen a rather large seminal reservoir from which a tube passes around the ovary to join the oviduct just anterior to the ovary. Anterior to the ovary and duct from the seminal reservoir, a small vitelline duct is seen to join the oviduct, after which there is formed the ootype, which merges into the shorter division of the uterus. The eggs in this first portion of the uterus are immature and it is not until they have proceeded to the anterior end of the worm, thence to the tail and return to the head that they seem fully developed and ready to be laid, or discharged through the genital pore. They are small—.005 mm., oval yellow, without filaments and very numerous.

The vitellarium, also in tubular form, extends almost the whole length of the worm; it is somewhat nodular and stains with carmine a yellowish brown. No vagina has been seen nor has a shell gland been found.

The *male genitalia* consist of a tubular testis which extends about two-thirds the length of the worm beginning near the anterior bend of the uterus. It stains pinkish. At the posterior end of the testis the vas deferens is given off; this is as usual a convoluted tube which extends anteriorly to the atrium situated, as viewed from the ventral surface of the worm, behind the mouth. No cirrus is visible.

The characters of the worm for the purposes of classification may be given as follows: Flat, ribbonlike, very narrow throughout, but very attenuated towards the anterior end; uterus in two or three tubes extending uncoiled throughout nearly from one end to the other; the ovary also tubular, but not nearly so long as the uterus. Vitellarium and vas deferens are also single tubes; the former nearly half as long as the uterus. The testis is also tubular and the vas deferens extends through nearly three-fourths of the length of the worm to the end at the genital atrium at the mouth. Living in great numbers, tangled together under the mucosa of the gill cavity of marine fishes, *Sarda,* etc.

This worm was found in material at the U. S. Bureau of Fisheries laboratory, at Wood's Hole, and the work in its study was carried out at that laboratory.

Measurements—tail end.

From bend of uterus to termination	.15 mm.
Tail width at bend of uterus	.14 mm.
Tail end of vitellaria from end	.12 mm.
Tail end from beginning of ovary	1.35 mm.
Width of ovary near tail end	.02 mm.
Width of vitellaria opposite tail end of ovary	.02 mm.

Head end.

Tip of head end from bend of uterus	.13 mm.
Width of worm across bend of uterus	.12 mm.
End of vitellaria at bend of uterus from tip end	.15 mm.
Vas deferens seen alongside vitellaria through much of its course, width of one column of uterus near anterior end, wide part	.02 mm.
Width of adult worm	.60 mm.
Length, probably 5 or 6 inches	
Egg	.005 mm.

Atalostrophion promicrops nov. sp.

On March 31, 1914, portions of a worm of the same genus as *A. sardæ* were found on the gills of a large Jew fish, (*Promicrops guttatus*) at the New York Aquarium. It was only discovered after the body had been disposed of, so that unfortunately the branchial cavity was not examined as it should have been, for no doubt more worms would have been found under the mucous membrane there.

One portion of worm found was about two inches long by .60 mm. wide. It was more muscular than that found in *Sarda sarda* and not so thin and delicate. It contained the same organ; the uterus, however, only showed a single tube filled with eggs. This, too, is a new species and will be fully described when further material is secured. I would in the meantime propose the name *Atalostrophion promicrops.*

The eggs are about of the same size and color as in *A. sardae* and the body, although thicker, is about .60 mm. in width.

Since the present paper has been in press, I have had occasion to examine a number of fish fresh from the sea, among

them two snappers, (*Priacanthus cruentatus*) whose death was certainly caused by *Diplectana.* The gills were infested by them, literally in thousands; in such numbers as I had never seen before. I have thought the fact of such importance that it should be recorded in connection with the above paper.

G. A. Mac.

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